IOWA ARMY AMMUNITION PLANT

Feasibility Study for the Installation of a Steam Dispatching Control System (SDCS) at the Iowa Army Ammunition Plant (IAAP)

FINAL 21 April 1995

Performed as part of the
Energy Engineering Analysis Program (EEAP)

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
P.O. BOX 9005
CHAMPAIGN, ILLINOIS 61826-9005

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REPLY TO
ATTENTION OF

CEMRO-ED-MC (415-10e)

21 April 1995

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Steam Dispatching Control System Feasibility Study, Energy Engineering Analysis Program (EEAP), FY94, Iowa Army Ammunition Plant, Middletown, IA

1. Enclosed for your information and file are the responses to the review comments of the Final Draft of the above study. Also enclosed are the review comments and a CECER-FE Memorandum, dated 23 February 1995. This concludes the work on the study.

2. If you have any questions regarding this EEAP Study, please contact Mr. Stan Owens, phone (402) 221-4523.

FOR THE COMMANDER

Encls

Charles J. Denne, P.E.
Chief, Army/Installation
Support Section
Military, Civil Engineering
Management Branch

DISTRIBUTION:
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Commander, Iowa Army Ammunition Plant, ATTN: SMCIO-PPE (L. Baxter), Middletown, IA 52638-5000
Iowa Army Ammunition Plant, Mason & Hanger, ATTN: L. Nihart, Middletown, IA 52638-5000
Commander, U.S. Army Engineer District, Mobile, ATTN: CESAM-EN-DM (T. Battaglia), P.O. Box 2288, Mobile, AL 36628-0001

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
P.O. BOX 9005
CHAMPAIGN, ILLINOIS 61826-9005

REPLY TO
ATTENTION OF

CECER-FE (70-1y)

23 February 1995

MEMORANDUM FOR Commander, U.S. Army Corps of Engineers,
Omaha District, 215 North 17th Street,
ATTN: CEMRO-ED-MC/Mr. Stan Owens, Omaha, NE
68102-4978

SUBJECT: Response to Comments on Steam Dispatching Control System Feasibility Study, Energy Engineering Analysis Program (EEAP), 1994 for Iowa Army Ammunition Plant (IAAP)

1. Enclosed are the responses to the Final Draft review comments from both IAAP and CESAM-EN-DM. After reviewing the comments with IAAP personnel, it was decided that no revisions were needed on the study; however, the concerns stated in the review comments should be answered and distributed as an addendum to the Final Report. The addendum is attached and will be sent to Mr. Stan Owens, CEMRO-ED-MC, for distribution to all addresses in Annex D of the Scope of Work.

2. If there are any additional comments or questions concerning these responses or the study, please contact me at (217)398-5510.

Chris Dilks

Encl

CHRIS DILKS
Electrical Engineer
Fuels & Power Systems Team

Addendum to Steam Dispatching Control System Feasibility Study at the Iowa Army Ammunition Plant

Response to review comments of the Final Draft

IAAP Comments:

1. Concern about "manual" PRVs and maintenance requirements.

The system described in the study is a fully automatic system which is controlled from a central location. Maintenance for the FM telemetry system and the control system, including the control PRV, can be subcontracted out to the manufacturers/installers of that particular piece of equipment. Little additional maintenance work would be required by the Preventative Maintenance Program.

2. Effect of lowering steam pressure on PRV capacities.

The effect of lower input steam pressures on the building PRV capacity is discussed on page 8 and in Appendix D and Appendix E. The last sentence of the first paragraph of the Model Results section pretty much matches comment #2 word for word. However, in speaking with Dick Luttenegger, we felt that a majority of the PRV's feeding heating systems would not need replacement. PRV's feeding process loads would be evaluated individually. Those that could not provide the required steam flow at the lower pressures would have to be replaced for SDCS to function properly.

3. Shutting off steam lines remotely

The system recommended in the report would allow the individual steam lines to be shut off from a central location. A very conservative estimate was used to calculate an hourly savings for each line for the times when it was shut down. These savings were not incorporated into the LCCID study because it was difficult to determine the exact number of hours the lines could be shut down. Addition of these savings would just increase the annual savings of the system and decrease the payback period.

4. Line 2 or 3 would be first choice.

I mentioned this early in the study, but Dick Luttenegger thought that it would be easier to fund the entire project at one time than to send separate projects through. Also the cost of the FM system was divided equally among the three lines. The cost for the system installed on only one steam line would be about $60,000, almost twice the cost used for a single line in the estimate. Additional lines would cost at least $15,000 each if added incrementally. The high cost for the programming of the centrally located computer and its auxillary equipment was equally divided into three lines for the study. It would be less expensive to install all three lines.

CESAM-EN-DM Comments:

1. None

2. No project Documentation.

Since the total project cost is less than $300,000 it does not qualify for ECIP Funding. Therefore Section 5.2 of the General Scope of Work for a Limited Energy Study was used as a guideline for project documentation. This requires a LCCA Summary sheet (Page 15), a description of work to be accomplished, backup data for the LCCA, energy savings calculations and cost estimates, and the simple payback period, which are found in the body of the report or referenced in the appendices. IAAP personnel agreed to fill out and submit the proper forms, if approved, using the results presented in the report.

3. SHDP abbreviation.

The Steam Heat Distribution Program (SHDP) was used to model the 3 distribution systems analyzed for this study. This program and its user manual can be obtained from the Defense Technical Information Center (DTIC). I added the executive summary and a couple of sentences in the body of the report after the first review of the report and forgot to define SHDP. It is defined on page 8.

4. Define baseline heating load.

Correct, the Baseline heating load is the load due to process loads and hot-water heaters. It is usually assumed to be the only load when the ambient is above 65 degrees F.

5. Discussion of Model Results a bit hard to follow.

Discussed model results over the phone with IAAP personnel. Cleared up any questions about the analysis during discussion. Will provide a more concise discussion of the results if still necessary.

6. Total Use columns of Table 7.

The Total Use columns of Table 7 are estimates of the steam usage before reducing steam pressure. They were used to calculate a total annual coal and natural gas consumption for the base. This annual usage was compared to an earlier EEAP study to validate the model.

7. Does standalone controller have a fail-safe requirement.

Standalone controller has 4 hour battery backup to prevent failures due to loss of line voltage. Control valve can be designed to fail to open, fail to close, or preferably fails to last setting upon loss of either control signal or line voltage. Standalone controller will power on in manual mode and must be reset to automatic mode after a failure that shuts down the controller occurs (i.e extended power outage where battery is drained). Controller can be programmed to set the maximum rate of travel of the control valve to eliminate unwanted rapid swings in steam pressure and flow. A program to startup and shut down lines will be programmed on the computer at the central location. These programs will contain multiple checks to ensure that the valves are opened and closed in a safe manner. The rate of change of the steam flow, steam pressure, and position of the valve will be limited to prevent rapid opening or closing of the valve.

8. Does cost include central computer.

The central computer was not included in the original cost because I thought that an existing computer on the base could be used. A new 486 based machine should be purchased and should have been included in the cost estimate. A new 486 based machine with a minimum of a 300 Mbyte Hard Drive, 8 MB of RAM and a super VGA monitor will cost less than $3000. A list of compatible machines should be obtained from the FM radio system/controller manufacturer. Choose an appropriate computer from this list.

9. Delete " for line 4" from first sentence..

Correct.

DEPARTMENT OF THE ARMY
IOWA ARMY AMMUNITION PLANT
17571 STATE HIGHWAY 79
MIDDLETOWN, IOWA 52638-5000

REPLY TO
ATTENTION OF:

SMCIO-PPE

6 October 1994

MEMORANDUM FOR Commander, U.S. Army Corps of Engineers, Omaha District, 215 North 17th Street, ATTN: CEMRO-ED-MC (Mr. Stan Owens), Omaha, NE 68102-4978

SUBJECT: Steam Dispatching Control System Feasibility Study, Energy Engineering Analysis Program (EEAP), FY94, Iowa Army Ammunition Plant, Middletown, IA

1. Reference memorandum, USCOE, CEMRO-ED-MC, 22 September 1994, SAB.

2. We are enclosing the operating contractor's correspondence dated 5 October 1994, transmitting our review comments for the subject document.

3. We have reviewed this listing and concur.

4. POC is Mr. Leon D. Baxter, SMCIO-PPE, Plant Protection Office, DSN 585-7101 or commercial (319) 753-7101.

LEON D. BAXTER
Environmental Engineer

Encl

Mason & Hanger-
Silas Mason Co., Inc.

ENGINEERS AND CONTRACTORS
FOUNDED 1827

17575 ST. HWY 79
MIDDLETOWN, IOWA 52638

5 October 1994

EN 94-065/L

Administrative Contracting Officer
Contract No. DAAA09-91-Z-0006
Iowa Army Ammunition Plant
Middletown, Iowa 52638

Dear Sir:

Subject: Steam Dispatching Control System Feasibility Study, Energy Engineering Analysis Program (EEAP), 1994 Iowa Army Ammunition Plant, Middletown, Iowa

Reference: CEMRO-ED-MC Memorandum Dated 22 September 1994

The following comments are provided in response to the referenced memorandum:

1. Due to the limited manpower any type system that will have "manual" Pressure Relief Valves (PRVs) will be met by resistance. Any system requiring substantial maintenance, unless the maintenance is subcontracted out would be a burden on the Preventative Maintenance Program.

2. The assumption that we can arbitrarily lower distribution steam pressure may be wrong. Each of the building's heating systems and process systems have PRVs, some buildings have several. The volume of steam required for process, especially, is a function of size of PRV and upstream pressure. Most of these were sized for upstream pressure of approximately 150 psig, therefore Mason & Hanger believes that arbitrary reduction in the upstream pressure may affect some of the processes by starving steam flow.

3. The major savings on a steam dispatch system can be achieved by totally shutting off steam to areas when it is not needed, i.e., each spring and fall on weekends when danger of freezing temperatures is not present, and during the summer on weekends and other times when the lines are not active. The ability to shut these selected areas off from steam and to start up slowly so as not to damage the mains at a single remote location is the best approach and will satisfy Mechanical that we are not putting in a system that they don't have the people to operate, or maintain.

4. Line 2, or Line 3 would be first choices if we were to increment the new process to thoroughly test before building a complete system.

Point of contact is L. L. Nihart, (319) 753-7806.

Sincerely,

MASON & HANGER-SILAS MASON CO., INC.

P. A. Richardson
Division Manager
Engineering

PAR/LLN/eh

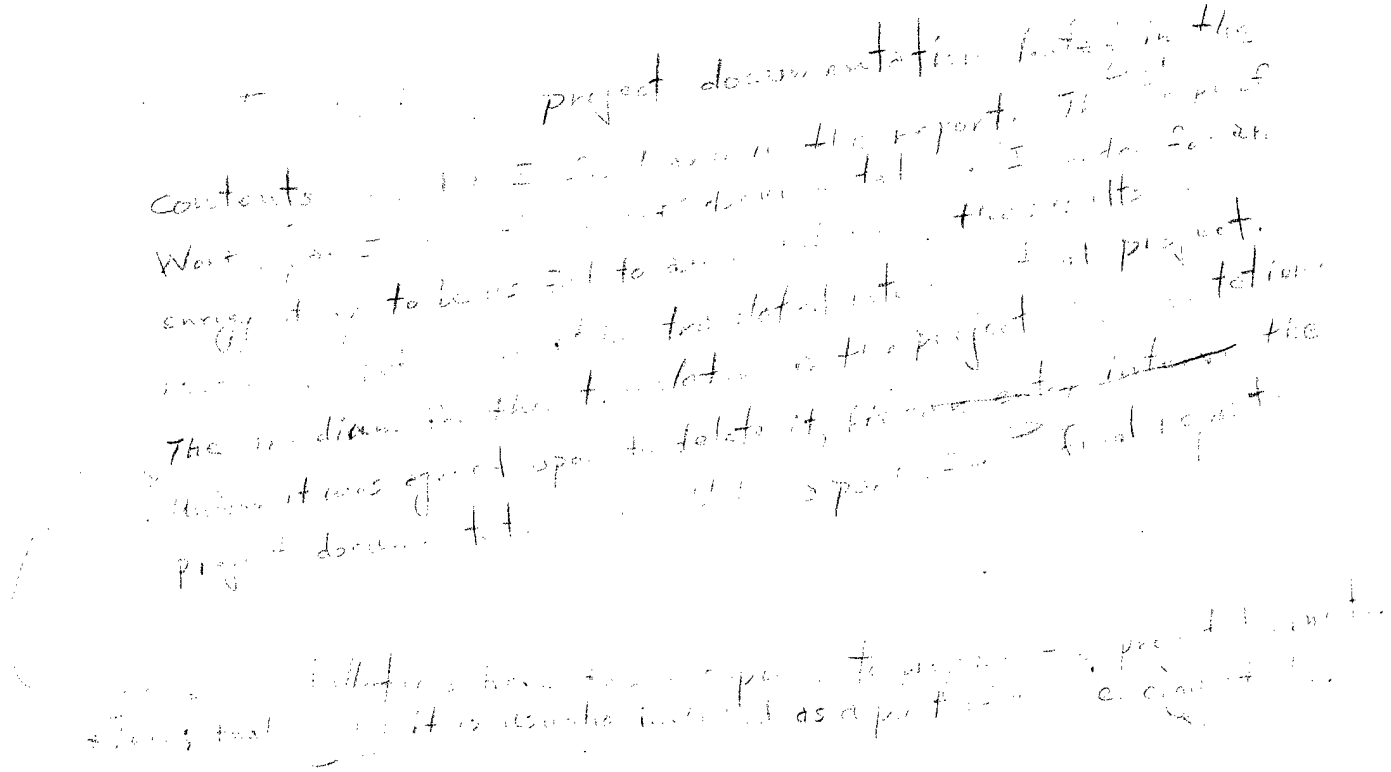
MOBILE DISTRICT PROJECT REVIEW COMMENTS		Date: 26 Oct 94	Page 1 of 2
To: Stan Owens Omaha District, CEMRO-ED-MC	From: (Section) CESAM-EN-DM (Reviewer) A. Battaglia		205-690-2618
Project: EEAP Study, Steam Dispatch Control System Location: Iowa Army Ammunition Plant, IA	Year: FY-94	Line Item No.:	
Type of Action: Final Draft review			

ITEM NO.	DRAWING NO. OR PAR. NO.	COMMENTS	REVIEW ACTION
1.	General	The approach taken on this study is very good from a technical and practical point of view. The analysis is thorough and well-presented.	
2.	Contents	I don't see project documentation listed in the contents, nor did I find any in the report. The General Scope of Work, par 5, calls for project documentation. For an energy study to be useful to an installation, the recommendations must be translated into an actual project. The medium for doing this is the project documentation. Very few installations have the resources to prepare the project documentation themselves; that is why it is usually included as part of the energy study. Unless there was a prior agreement to delete it, the project documentation should be a part of the final report.	
3.	Page 1	The abbreviation "SHDP" is used frequently throughout the report. It should be defined the first time it is used.	
4.	Page 4	Please clarify or define the term "baseline heating load". Is this the load when the ambient temperature is 65^{0}F?.	
5.	Pg 8 & 9	The discussion of the Model Results is a bit hard to follow. Please try to separate the discusion on the validity of the model from the rest of tthe discussion.	
6.	Page 10	Table 7: For the three "Total Use" columns at the right of the table, is this total use before or after reducing the distribution pressure?	
7.	Page 13	Regarding the standalone controller, does it have a fail-safe requirement?	

PROJECT REVIEW COMMENTS (Continuation Sheet)		Date: 26 Oct 94	Page 2 of 2
Project and Location: EEAP Steam Dispatch Study Iowa AAP, IA		FY-94	Section: CESAM-EN-DM
			REVIEW ACTION

ITEM NO.	DRAWING NO. OR PAR. NO.	COMMENTS
8.	Page 13	Second sentence of par 5: Does the $213,271 cost also include the computer?
9.	Page 14	Delete the words, "for line 4" from the first sentence.

Contents



TABLES

FIGURES

1 EXECUTIVE SUMMARY

Federal mandates require Army installations to reduce energy consumption by 30 percent over 1985 levels by the year 2005. In accordance with this outlook, researchers at the U.S. Army Construction Engineering Research Laboratory (USACERL) examined the feasibility of installing the Steam Dispatching Control System (SDCS) at the Iowa Army Ammunition Plant (IAAP). SDCS is a control system for reducing the losses in a distribution system by lowering the steam pressure to slightly above the amount needed to meet the thermal demand. This results in a lower steam temperature, with only slight reductions in steam enthalpy. Thermal losses and leak losses are reduced as the temperature and pressure are reduced. The past success of SDCS in industry indicated that SDCS could be successfully applied to military district heating systems.

After analyzing the IAAP base maps, three areas at IAAP were found to have the physical characteristics suitable for the SDCS. These areas include Line 2, Line 3, and Line 4B/Admin. Lines 2 and 3 consisted of 17 and 18 buildings, respectively, which include manufacturing, office, and warehouse space. Line 4B/Admin consists mostly of office, shop, and warehouse space. A hospital and gym are also on this line. During the winter line 4B/Admin feeds 20 buildings, however, steam to the Admin area is shut off during the summer months, and the line feeds only 7 buildings in the 4B area. Approximately 60 percent of the steam lines in the 4B/Admin area are shut off in the summer.

No steam flow readings area available for the individual lines since individual steam flow meters do not exist. Therefore steam flow projections were made from models developed using SHDP and a projected steam usage chart from R. H. Tiemeier of IAAP. The steam demand and required steam pressure for each building was taken from a previous EEAP study. Values for the heat loss coefficients of the pipe and minimum and maximum flow rates for each line also came from a table developed by R. H. Tiemeier of IAAP. Steam trap losses were estimated from a survey of the steam system. Tables 1 and 2 show the heating season and summer loads and savings for the three lines.

Table 1. Heating Season Steam Flow Model Results for Lines 2, 3, and 4B/Admin

	Line 4 Savings	Line 2 Savings	Line 3 Savings	Line 4 Total Use	Line 2 Total Use	Line 3 Total Use
Total (1000 lbs steam)	5576	2590	2446	77652	52266	50289
Total (MBtus steam)	7137	3315	3131	99395	66900	64369
Total (MBtus Coal)	11151	5180	4892	155305	104531	100577
Coal @ $1.39/MBtu	$15,500	$7,200	$6,800	$215,874	$145,298	$139,802
Coal @ $1.64/MBtu	$18,288	$8,495	$8,023	$254,700	$171,431	$164,947

Table 2. Summer Steam Flow Model Results for Lines 2, 3, and 4B

	Line 4 Savings	Line 2 Savings	Line 3 Savings	Line 4 Total Use	Line 2 Total Use	Line 3 Total Use
Total (1000 lbs steam)	1000	1800	1800	16200	18000	18000
Total (MBtus steam)	1160	2088	2088	18792	20880	20880
Total (MBtus Nat Gas)	1546	2784	2784	25056	27840	27840
Nat Gas @ $3.50/MBtu	$5,411	$9,744	$9,744	$87,696	$97,440	$97,440

Annual coal consumption based on the steam demand for the three lines totals 360,413 MBtus of which 5.9 %, or 21,223 MBtus, could be saved. Annual natural gas consumption due to steam demand for the three lines totals 80,736 MBtus of which 8.8 %, or 7114 MBtus, could be saved annually. Annual energy consumption would be reduced from 444,149 MBtus ($783,550) to 415,812 MBtus ($729,151) after implementation of the SDCS on the three lines. Using $1.39/MBtus and $3.50 as the price for coal and natural gas, respectively, the annual savings would be $54,399. Subtracting $3,000 for annual maintenance results in a net annual savings of $51,399. This results in a savings to investment ratio (SIR) of 2.84 and simple payback period of 4.87 years.

Points of Contact:

Chris Dilks, CECER-FEP
USACERL, PO Box 9005
Champaign, IL 61826-9005
(217) 398-5510, fax: (217) 373-3430

Ralph Moshage, CECER-FEP
USACERL, PO Box 9005
Champaign, IL 61826-9005
(217) 398-5544, fax: (217) 373-3430

2 INTRODUCTION

Background

Currently most military district steam heating systems operate by maintaining a constant steam pressure regardless of actual steam demand. This method of operation, while practical, is often the source of significant energy losses. Energy conservation is a national goal and may perhaps be a future necessity. In accordance with this outlook, researchers at the U.S. Army Construction Engineering Research Laboratory (USACERL) examined the Steam Dispatching Control System (SDCS).

SDCS is a control system for reducing the losses in a distribution system by controlling the steam pressure. Lowering the steam pressure to slightly above the amount needed to meet the thermal demand reduces the steam temperature with only slight reductions in steam enthalpy. Thermal losses at the lower temperature are reduced and leak losses are also diminished. The past success of SDCS in industry indicated that SDCS could be successfully applied to military district heating systems.

Objective

The Iowa Army Ammunition Plant must meet energy reduction goals mandated by Congress. IAAP operates and maintains a substantial steam distribution system consisting of approximately 13 miles of steam lines. Currently 150 to 175 psig steam is produced at the boiler plants and fed into the system even though some sections of the system require only 15 - 60 psi steam. This practice can result in excessive thermal losses and leak losses. A comprehensive model of the steam distribution system will assist in targeting areas where SDCS could be applied to save energy. This model could also serve as an aid in the development of plans for renovation or expansion of the existing system.

In addition to the modeling process, a safe and reliable method of controlling the pressure reducing stations needs to be developed. Preferably the valves will be controlled from a central location such as one of the heating plants. Development of this technology will also allow the pressure reducing valves to be used as shutoff valves that can be operated from a central location.

3 STEAM SYSTEM MODELS

Model Development

The first step in modeling the steam system is to choose areas that have favorable characteristics for SDCS. Three areas stand out as candidate sites; Area 2, Area 3, and Area 4B/Admin/Shop. The other areas are either too small or have steam fed from two or more locations. Figures 1, 2, and 3 show the general layout of the three candidate areas. These were produced using drawings supplied by IAAP personnel. Pipe sizes and lengths are tabulated from these drawings. Tables of the buildings and their steam use for each area were compiled by IAAP personnel and can be found in Appendix A. These tables consisted of a design building load and an annual building

consumption. From these numbers a baseline heating load and slope were derived. The baseline heating load (in Btu/hr) was calculated by one of two means. If the table listed no design load for a building, the annual heating load, in MBtus, was divided by 8760 hours to get the baseline load for the building. The baseline loads for buildings in areas shut-off during the summer were calculated by dividing the annual consumption by 5400 hours. A slope of zero (0) was assigned to these buildings, which assumes that the building steam demand is constant. If a design load was given, the baseline load was assumed to be 1/7 of the design load. This is consistent with the models used at Fort Benjamin Harrison, which has a similar climate. The slope of the demand (Btus/hr-°F) was calculated by taking the difference between the design load and the baseline load, and dividing it by 82. This assumes a design temperature of -17 degrees F (65 - (-17) = 82). To verify the models, the total baseload and slope for each model were used along with the temperature data in Table 3 to calculate the annual steam consumption in MBtus. There was good agreement between the calculated consumption for the SHDP models and the values in Appendix A.

Values for the baseload and slope are assumed to be in lbs/hr in the SHDP input file. For this study I did not convert the slope and baseload values from Btu/hr to lbs/hr, which is an assumption of 1000 Btu per pound of steam of useful energy at the buildings. For a system that converts 15 psig saturated steam to 150 °F condensate the useful energy is actually 1036 Btu/lb. Thus flow rates for the model will be 3.6 percent higher than expected. This was done to ensure that the pressure drop in the model system would be at its maximum, which results in set points for the SDCS that are sufficiently high. This assumption does not produce a noticeable effect on the heat loss of the system or the projected savings, but it will produce slightly higher than expected annual consumption values.

Values for the heat loss of the lines are taken from a table compiled by R. H. Tiemeier of IAAP (see Appendix B). The numbers in Table 3 represent the average heat loss of the various pipe sizes in still air. Wind has a dramatic effect on convective heat losses. To calculate this effect you must multiply the heat loss in still air by the factor:

$(1 + 1.2775 * \text{Wind Speed(mph)})^{1/2}$ (1993 ASHRAE Handbook Fundamentals).

An average wind speed of 10 mph (the mean wind speed is 10.2 mph) is used in the analysis, which increases the heat loss by 3.7 times. Table 3 also shows the heat loss values of the various pipe sizes calculated using 5, 10, and 20 mph wind speeds. Total heat loss rates of the system for various wind speeds will be nearly proportional to these factors.

Table 3. Heat Loss Coefficients for Above Ground Steam Lines

Pipe Diameter (Inches)	Heat Loss (no wind) Btu/hr-ft-°F	Heat Loss (5 mph wind) Btu/hr-ft-°F	Heat Loss (10 mph wind) Btu/hr-ft-°F	Heat Loss (20 mph wind) Btu/hr-ft-°F
1.5	0.141	0.383	0.520	0.727
2	0.154	0.419	0.571	0.794
2.5	0.168	0.457	0.623	0.866
3	0.185	0.503	0.685	0.953
4	0.211	0.573	0.782	1.087
6	0.265	0.720	0.981	1.365
8	0.314	0.853	1.162	1.618

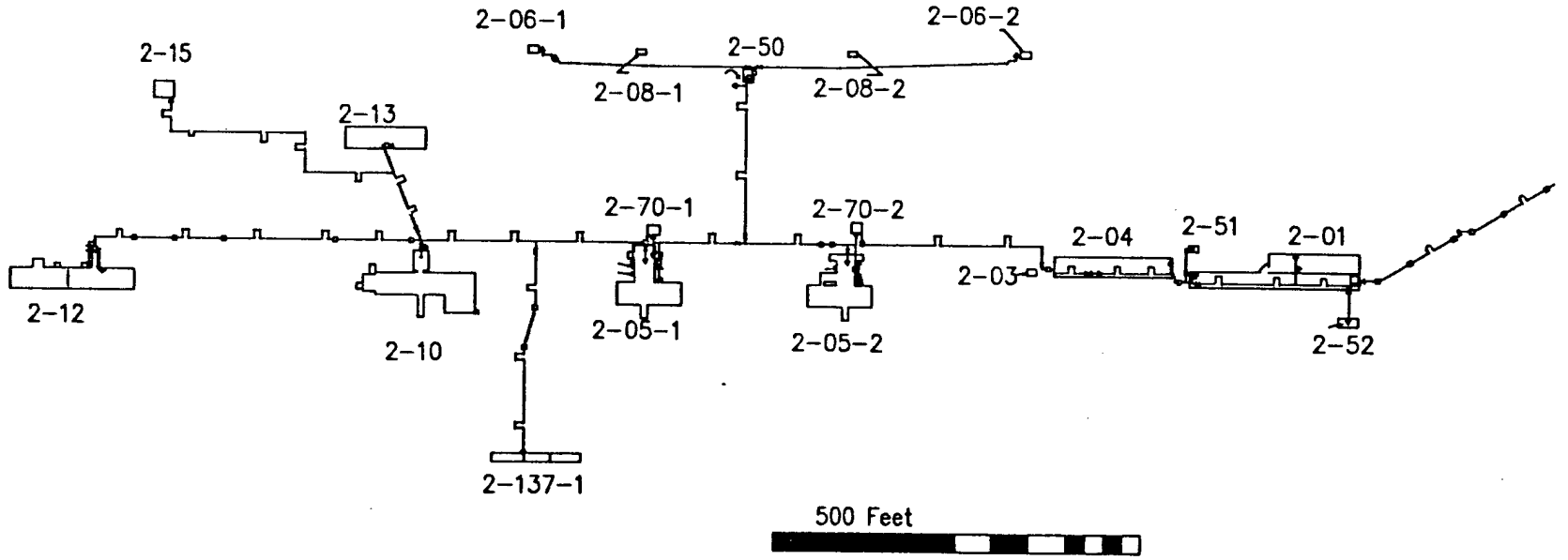


Figure 1. Area 2 Steam Distribution System

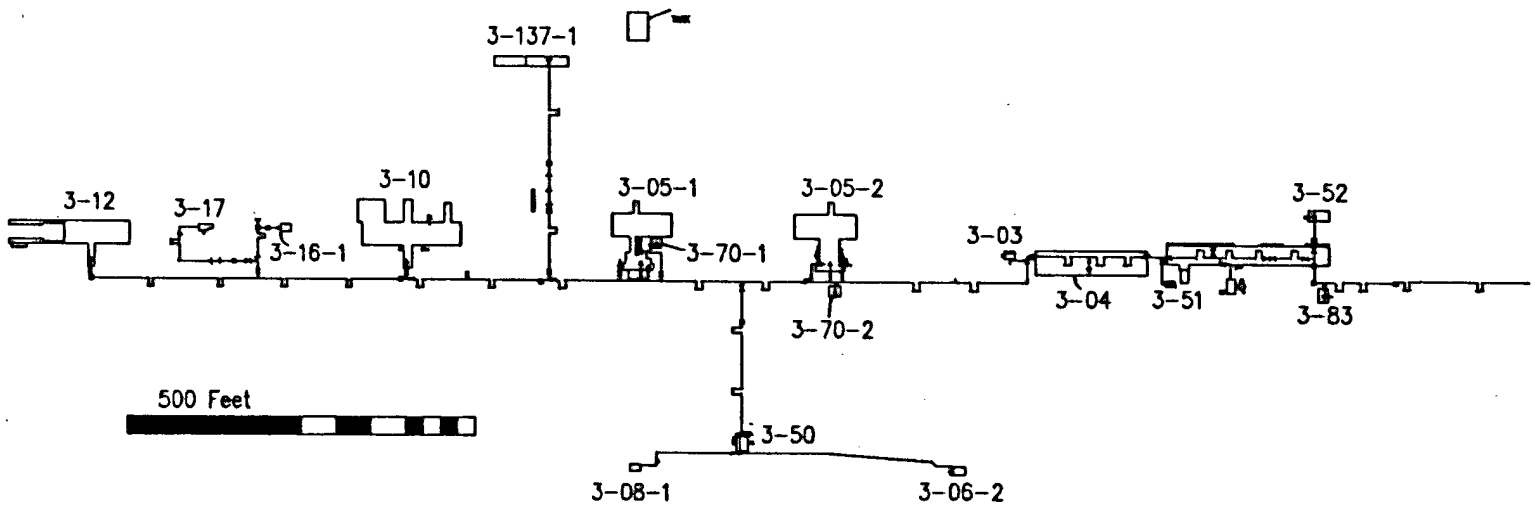


Figure 2. Area 3 Steam Distribution System

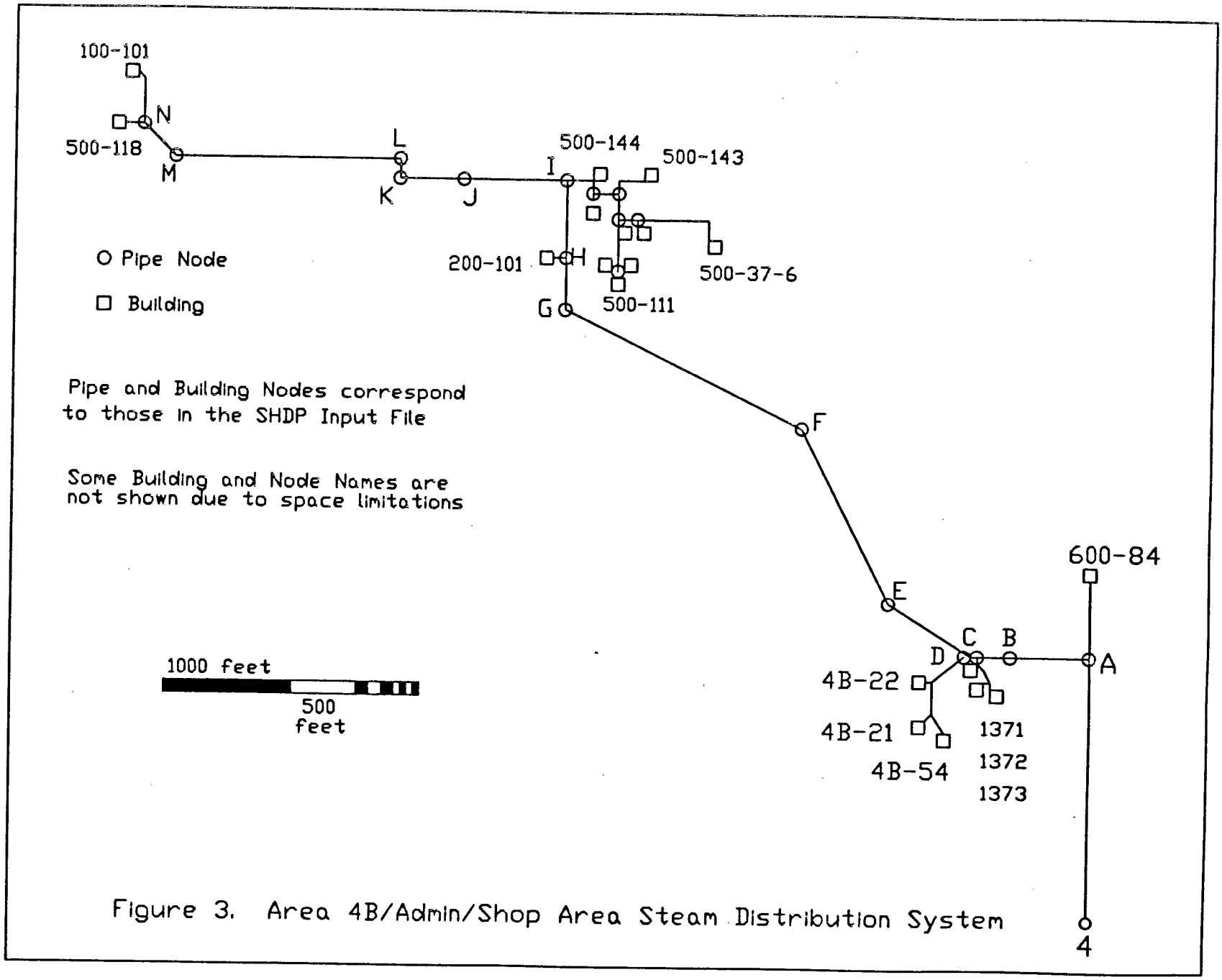


Figure 3. Area 4B/Admin/Shop Area Steam Distribution System

The next step consisted of creating the input files for the Steam Heat Distribution Program (SHDP). Appendix C contains the actual input files for the three areas. An ambient temperature of 65 degrees F and the presence of 155 psig saturated steam at the take off from the main steam line are assumed in the files of the steam use models in Appendix C. Pipe roughness values are taken from an example of the Oak Ridge Steam System in the SHDP Users Guide and are typical of older schedule 40 and schedule 80 steel pipes Valve sizing coefficients are left as unknowns and are calculated by SHDP. It is assumed that a 15 psi pressure differential is required by the pressure reducing valves at the building in order for them to meet the demands of the buildings (75 psig steam is required for the input to the PRV for 60 psig output). A steam trap failure rate of 5 percent is also assumed. The field survey indicated approximately one trap every 500 feet and a trap at every building, however the SHDP model assumes a trap at every node and many nodes in the model were up to 2000 feet apart. Therefore the 5 percent trap failure used in the model would represent an actual rate of failure of 2 - 3 percent. This would be indicative of a very good trap maintenance program. All traps are discharged to the atmosphere. A higher rate of trap failure would result in even more savings from the SDCS.

Model Results

The models for each area were run through SHDP using 5 temperatures ranging from -15 to 65 degrees F in 20 degree increments. Two runs were made at each temperature, one for the existing system and on for the system with the SDCS. The existing model assumed an input pressure to the system of 155 psig saturated steam. The low pressure node (building) in the system was recorded and used to calculate the set points for the SDCS system. To calculate both steam usage and the set points for the system with SDCS the low pressure node was set to 75 psig and the input pressure was set to an unknown status and calculated by SHDP. This calculated value is your setpoint for the particular temperature. Lowering the input pressure of the building PRV's to 75 psig reduces their capacity to roughly 40 percent of their capacity at 150 psig (see Appendix D: Steam Trap and Pressure Reducing Valve Capacities) for a 60 psig output pressure. However the PRV's should still should have sufficient capacity to meet the demand, if they are in good working condition, since the PRV's were sized for the buildings before the buildings were insulated. Insulation of the buildings resulted in a decrease of the total base steam consumption by over 50 percent (Phone Conversation with Dick Luttenegger). A table of minimum PRV sizes can be found in Appendix E. These were derived by looking at the maximum flow for each valve from the models at -15 degrees F, and looking up the correct size from the manufacturer's valve specification sheet. A quick check showed that all of the valves are properly sized assuming they match the input pipe size to the building, however, all PRV's that feed process steam will need to be evaluated on a individual basis.

Armstrong Model 2011 stainless steel traps with an orifice size of 7/64 " are used at all locations at IAAP. All traps at IAAP are vented to the atmosphere. Lowering the pressure from 150 psig to 75 psig would reduce the steam trap capacity from 750 lbs/hr to 600 lbs/hr. During the field survey it was noted that the traps on the larger pipes were cycling slowly, discharging during about 1/3 of the cycle. Also, the steam system models showed a maximum condensation rate of 350 lbs/hr per 500 feet of pipe. This high condensation rate was observed only on the 6 and 8 inch pipes.

Results from the modeling procedure for areas 2, 3, and 4 are shown also shown in Table 4. The calculated controller set points for the steam pressure at the four temperatures are shown in Table 5. These would be used as starting points and can be easily modified to insure adequate

steam flow to all buildings. Since there are not separate flow meters for these three lines, verification of the models was accomplished using two sets of data compiled by IAAP personnel. The first set of data consisted of the maximum steam flow that was expected in each line. This data was calculated by R. H. Tiemeier based on his experience with the system (see Appendix B). The second validation procedure consisted of comparing the calculated load of each area as a percentage of the total load measured at the steam plant. Additional runs were made at temperatures for which the total plant output was known. These comparisons can be seen for 4 different temperatures in Table 4. It was assumed that the percentage load of each area would remain relatively constant over the entire range of loads.

Table 4. Steam Flow Comparison

Outdoor Temp	Total Flow lbs/hr)*	Line 2 Flow lbs/hr)	Line 2 %	Line 3 Flow lbs/hr)	Line 3 %	Line 4 Flow lbs/hr)	Line 4 %	Total Flow lbs/hr)	Total %
-20	120000	20000	16.7	19500	16.3	26500	22.1	66000	55.0
10	70000	15000	21.4	14200	20.3	21000	30.0	50200	71.7
42	56000	8800	15.7	8500	15.2	13400	23.9	30700	54.8
65	40000	5200	13.0	5100	12.8	9000	22.5	19300	48.3

* Single Boiler plant readings may be not be representative of actual averages

Table 5. Controller Set Points

Outdoor Temp	Line 2 set point psig	Line 3 set point psig	Line 4 set point psig
-20	115	135	120
10	98	110	100
42	85	90	85
65	80	80	80

The savings on each line was calculated by comparing the steam consumption for the two models at the various temperatures. Quadratic regressions were calculated relating the savings to the outdoor temperature. The climate data for the Moline, IL Airport is shown in Table 6 and the results of the model analysis are shown in Table 7.

The total steam usage during the heating season for lines 2, 3, and 4 added up to 180.2 million pounds of steam. Assuming that these three lines account for approximately 55 % of the total steam flow, the total steam usage during the heating season for the entire base would be approximately 327.7 million pounds (419,456 MBtus at 1280 Btus/lb for 450°F superheated steam at 175 psig). Assuming an average summer load of 30,000 lbs/hr, an additional 108 million pounds (125,712 MBtus at 1164 Btus/lb) of 150 psig saturated steam would need to be produced to meet the summer load.

Table 6. Hourly Temperature Occurrences for Moline, IL Airport

Temp Bin	Mean Temp	Hourly Occurrences OCT	NOV	DEC	JAN	FEB	MAR	APR	Total Hours
> 65	65	165	20				10	103	298
60/65	62.5	92	32	4		1	11	68	208
55/59	57.5	109	39	6	3	4	21	74	256
50/54	52.5	107	58	14	4	11	39	97	330
45/49	47.5	102	85	22	11	20	54	103	397
40/44	42.5	79	98	41	29	41	89	109	486
35/39	37.5	54	114	95	73	88	137	95	656
30/34	32.5	27	105	142	112	156	168	51	761
25/29	27.5	7	79	128	118	117	97	17	563
20/24	22.5	2	47	97	99	75	56	3	379
15/19	17.5		24	60	82	52	32		250
10/14	12.5		11	49	66	38	16		180
5/9	7.5		5	31	58	29	7		130
0/4	2.5		3	26	46	20	4		99
-5/-1	-2.5			15	22	12	1		50
-10/-6	-7.5			10	14	6	1		31
-15/-11	-12.5			3	6	2	1		12
-20/-16	-17.5			1	1				2
Total Hours		744	720	744	744	672	744	720	5088

Table 7. Steam Usage Model Results for Lines 2, 3, and 4

Temp Bin Deg F	Mean Temp Deg F	Line 4 Savings (lbs steam)	Line 2 Savings (lbs steam)	Line 3 Savings (lbs steam)	Line 4 Total Use (lbs steam)	Line 2 Total Use (lbs steam)	Line 3 Total Use (lbs steam)
> 65	65	360674	172259	163564	2681182	1554034	1518346
60/65	62.5	250452	119634	113450	1985307	1176405	1146910
55/59	57.5	304710	145594	137593	2723529	1673552	1625817
50/54	52.5	387622	185264	174257	3871416	2448080	2371558
45/49	47.5	459372	219621	205319	5090764	3294752	3184360
40/44	42.5	552955	264439	245355	6761885	4461195	4303243
35/39	37.5	732482	350397	322135	9841539	6598896	6354403
30/34	32.5	832205	398220	362097	12244557	8324397	8003895
25/29	27.5	601683	287999	258485	9670410	6653432	6388611
20/24	22.5	394922	189090	167127	6921221	4811961	4614748
15/19	17.5	253368	121353	105340	4836441	3393676	3250905
10/14	12.5	176957	84783	72053	3677125	2601455	2489392
5/9	7.5	123614	59246	49111	2796289	1992893	1905165
0/4	2.5	90765	43519	35026	2236421	1604488	1532432
-5/-1	-2.5	44046	21127	16419	1183452	854177	815097
-10/-6	-7.5	26139	12543	9346	767148	556752	530831
-15/-11	-12.5	9643	4630	3278	309877	226026	215329
-20/-16	-17.5	1524	732	487	53797	39422	37527
Total (1000 lbs)		5603	2680	2440	77652	52266	50289
Coal @ $1.39/MBtu		$15,577	$7,452	$6,784	$215,874	$145,298	$139,802
Coal @ $1.64/MBtu		$18,378	$8,792	$8,005	$254,700	$171,431	$164,947

The analysis was done using two fuel prices for coal; the current price of $1.39/MBtu and the expected future cost of $1.64/MBtu (as quoted from Dick Luttenegger). A plant efficiency of 64 percent was used (as quoted from Dick Luttenegger), resulting in a cost per 1000 lbs steam of steam of $2.78 and $3.28, respectively. The savings were calculated for the period October through April. The climate data (Table 6) consisted of the total number of hours per month that the temperature was in the various 5 degree temperature bins. The data was from the Quad Cities Airport, which was the closest location available for which data could be found. The hourly occurrences were totaled for the period between October and April, and were used along with the equation for the hourly steam savings to calculate the total savings for the heating season. The mean temperature of the bin was used in the hourly steam savings regression equation. Values for expected savings and total steam consumption for each temperature bin are also shown in Table 7.

The savings for the heating season ranged from around $7,000 on lines 2 and 3 to almost $15,500 on line 4 using the current fuel price of $1.39/MBtu. The expected savings increased to $8,250 and $18,250 using a fuel cost of $1.64/MBtu. This is an annual savings of 21,223 MBtus of coal. Assuming a temperature of 65 degrees or greater during the rest of the year, an average hourly savings of approximately 500 lbs/hr of steam should be seen on lines 2 and 3. This would result in an additional savings of an additional 1.8 million lbs of steam per line. The Admin and Shop areas of line 4 are shut off during the summer. Since these two areas comprise such a large percentage of the system on line 4, the summer savings of line 4 would be much smaller than the winter savings. An estimated savings of 300 lbs/hr of steam would be seen in the summer resulting in a total savings of about 1 million pounds of steam. During the summer 150 psig saturated steam is produced at Building 1-62 by natural gas fired boilers. The cost of steam per 1000 lbs during the summer is $5.43 ($3.50/MBtu of natural gas) assuming an overall plant efficiency of 75 percent. This would result in a summer savings of $9,750 for lines 2 and 3 and $5,400 for line 4, which is a total savings of 7114 MBtus of natural gas. Annual savings for lines 2 and 3 would be about $16,750 while line 4 should save nearly $20,000 per year with current fuel prices. The estimated steam flows during the summer are 5000 lb/hr for lines 2 and 3 and 4500 lbs/hr for line 4.

Additional savings can be expected due to the added capability of being able to remotely shut off areas during non-essential periods. Savings would come from the thermal and leak losses of the line which would be completely eliminated during these periods. These losses total about 2500 lbs/hr for lines 2 and 3 and 1500 lbs/hr for line 4 during the summer. This would result in daily savings of $326 for lines 2 and 3 and $195 for line 4. This additional means of savings was not included in the life cycle cost analysis.

4 EQUIPMENT AND LABOR COSTS

All equipment and labor costs were calculated using the 1993 Means Mechanical Cost Data Manual. A 20 % increase in labor cost was used because of the height of the line, which was estimated at 15 feet above ground. Detailed lists of equipment and labor costs required for the SDCS are shown in Tables 8 and 9. Total costs are based on two 8" lines and one 6" line. The 6" and 8" gate valves may already exist. Electrical service of 120/240 volts will need to be available at each location. A specification sheet for a Fisher control valve is included in Appendix F.

Table 8. Control Valve Piping and Instrumentation for 6" Line

Quantity	Description	Material Cost	Labor Cost
1	4" Fisher Control Valve and Electric Actuator	6500	250
1	6" Gate Valve (300# Flanged)	2550	210
2	4" Gate Valves (300# Flanged)	2900	280
4	4" Weld Flanges	120	270
4	6" Weld Flanges	200	500
2	6" by 4" Reducing Tees	740	205
2	90° Elbows - 4"	180	100
2	6" Orifice Plate Flanges	600	200
1	6" Orifice Plate	525	40
1	Differential Pressure Transmitter	1200	40
1	Pressure Transmitter	600	40
2	3 1/2 " Dial Pressure Gauges	25	15
5	3/4 " Globe Valves	505	125
5	3/4 " Weldolets	60	100
1	Misc Pipes and Fittings	300	500
1	Control Panel	250	50
1	Electrical and Control Wiring *	1000	5000
	Subtotal	**18255**	**7925**
	Contingencies (20%)	3651	1585
	Contractor Profit (10%)	1826	793
	Labor Adjustment for Overhead Lines (20%)		1585
	Total	**23732**	**11888**

Table 9. Control Valve Piping and Instrumentation for 8" Line

Quantity	Description	Material Cost	Labor Cost
1	4" Fisher Control Valve and Electric Actuator	6500	250
1	8" Gate Valve (300# Flanged)	3875	260
2	6" Gate Valves (300# Flanged)	5100	425
4	4" Weld Flanges	120	270
4	8" Weld Flanges	330	625
2	8" by 6" Reducing Tees	1260	250
2	90° Reducing Elbows - 6" to 4"	610	140
2	8" Orifice Plate Flanges	650	220
1	8" Orifice Plate	625	50
1	Differential Pressure Transmitter	1200	40
1	Pressure Transmitter	600	40
2	3 1/2 " Dial Pressure Gauges	25	15
5	3/4 " Globe Valves	505	125
5	3/4 " Weldolets	60	100
1	Misc Pipes and Fittings	300	500
1	Control Panel	250	50
1	Electrical and Control Wiring *	1000	5000

Subtotal	**23010**	**8360**
Contingencies (20%)	4602	1672
Contractor Profit (10%)	2301	836
Labor Adjustment for Overhead Lines (20%)		1672
Total	**29913**	**12540**

* Assumes 120 Volt Electrical service available within 150 feet

Technologies for the Remote Control of Pressure Reducing Valves

A few essential pieces of equipment are required to control the pressure reducing valves from the boiler house. First, a computer is needed at the boiler house to allow the operators to interface with the remote units. The computer will display data from the remote sites and allow the operators to manually control the PRVs. A transmitter/receiver is needed at the plant and the at each PRV site. Finally, a standalone controller is necessary to control the PRV. A temperature sensor to measure outdoor temperature and a pressure transducer to measure the steam pressure are needed at each PRV. The setpoint for the controller is determined from an equation relating the setpoint and the outdoor temperature. This equation was derived from the modeling process and is adjusted based on actual performance data. The controller must be able to operate independently from the central computer. A quote from Bristol-Babcock is included in Appendix G. This quote covers all control instrumentation and equipment ($76,051), programming of the Remote Terminal Units, and the central software program ($16,694). Installation and wiring is not included in the Bristoll Babcock quote but is covered under the electrical and control wiring task above. Three days of on-site technical support by a Bristoll Babcock representative are included in the labor section of that same task..

Companies offering telemetering and control systems include Bristol-Babcock, Motorola, Honeywell, USDATA, and many others. Many of these systems require a proprietary programming language which would necessitate either training someone at the base in that language or hiring the manufacturer to program the system. Base personnel should be trained to reliably perform routine procedures such as manual control of the valve, shutting off a line, bringing the line back up, and turning the controller on and off. At least one person should be trained in reprogramming the controller in case of failure.

5 LIFE CYCLE COST ANALYSIS

Installation of the SDCS will cost approximately $213,271 for the three lines and these costs are shown in Table 10. This includes the PRV, controller, FM radio transmitters, wiring, valves, piping, and labor. Design costs and SIOH for the completed project will be around $25,000 and $12,000, respectively, bringing the total cost to $250,271. The SDCS would require approximately $3000 per year of additional maintenance. The maintenance consists of general upkeep, calibration, and repair of the equipment each year, as needed.

Table 10. Equipment and Labor Costs per Line

Area	Piping and Valve Equipment	Labor	Radio Equipment	**Total**
Line 2	$ 29,913	$ 12,540	$ 30,915	**$ 73,368**
Line 3	$ 23,732	$ 11,888	$ 30,915	**$ 66,535**
Line 4	$ 29,913	$ 12,540	$ 30,915	**$ 73,368**
Total	**$ 83,558**	**$ 36,968**	**$ 92,745**	**$ 213,271**

The inputs for the LCCID analysis for line 4 are shown in Table 11. Escalation factors for coal and natural gas are taken from the 1994 DOE tables in the LCCID program. The economic life of the project is assumed to be 15 years. Results of the LCCID analysis is shown in Table 12. Electrical consumption of the system was assumed to be negligible. Appendix H contains a printout of the LCCID output file for this study and a printout for a study where the fuel savings were set to half of the value used in the first study. The second study was done to test the sensitivity of the life cycle cost to the calculated savings. The payback periods for the two studies were 4.73 years and 9.74 years and savings to investment ratios (SIR) for the two studies were 3.77 and 1.84, respectively. Results based on the collected steam flow values will be used to verify the actual savings.

Table 11. LCCID Inputs for ECIP Study of SDCS at IAAP

Category	MBtus	($)
Initial Investment		213,271
Design Cost		25,000
SIOH		12,000
Annual Coal Savings	21223	29,500
Annual Nat. Gas Savings	7114	24,899
Annual Maintenance	0	1,500

Table 12. LCCID Results for Installation of SDCS on Lines 2, 3, and 4B/Admin

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: IAAP
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.080
INSTALLATION & LOCATION: IOWA ARMY AMMUREGION NOS. 7 CENSUS: 2
PROJECT NO. & TITLE: W54 FEASIBILITY STUDY FOR SDCS AT IAAP
FISCAL YEAR 1994 DISCRETE PORTION NAME: STEAM DISPATCHING
ANALYSIS DATE: 08-04-94 ECONOMIC LIFE 15 YEARS PREPARED BY: CHRIS DILKS

1. INVESTMENT

A. CONSTRUCTION COST	$ 213271.
B. SIOH	$ 12000.
C. DESIGN COST	$ 25000.
D. TOTAL COST (1A+1B+1C)	$ 250271.
E. SALVAGE VALUE OF EXISTING EQUIPMENT	$ 0.
F. PUBLIC UTILITY COMPANY REBATE	$ 0.
G. TOTAL INVESTMENT (1D - 1E - 1F)	$ 250271.

2. ENERGY SAVINGS (+) / COST (-)
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1993

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ .00	0.	$ 0.	11.93	$ 0.
B. DIST	$ .00	0.	$ 0.	13.49	$ 0.
C. RESID	$ .00	0.	$ 0.	14.96	$ 0.
D. NAT G	$ 3.50	7114.	$ 24899.	14.53	$ 361782.
E. COAL	$ 1.39	21223.	$ 29500.	13.00	$ 383500.
F. LPG			$ 0.	12.78	$ 0.
M. DEMAND SAVINGS			$ 0.	11.85	$ 0.
N. TOTAL		28337.	$ 54399.		$ 745282.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)	$ -3000.
(1) DISCOUNT FACTOR (TABLE A)	11.85
(2) DISCOUNTED SAVING/COST (3A X 3A1)	$ -35550.

B. NON RECURRING SAVINGS(+) / COSTS(-)

ITEM	SAVINGS(+) COST(-) (1)	YR OC (2)	DISCNT FACTR (3)	DISCOUNTED SAVINGS(+)/ COST(-)(4)
d. TOTAL	$ 0.	0.		

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-)(3A2+3Bd4) $ -35550.

4. FIRST YEAR DOLLAR SAVINGS 2N3+3A+(3Bd1/(YRS ECONOMIC LIFE)) $ 51399.

5. SIMPLE PAYBACK PERIOD (1G/4) 4.87 YEARS

6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) $ 709732.

7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)= 2.84
(IF < 1 PROJECT DOES NOT QUALIFY)

8. ADJUSTED INTERNAL RATE OF RETURN (AIRR): 10.52 %

6 RECOMMENDATIONS

Based on the results of the life cycle analysis installation of the Steam Dispatching Control System on the three lines at IAAP would result in an annual savings of over $50,000 with a payback of just under 5 years. Drawings of the control valve piping layout from Fort Harrison were given to IAAP personnel to assist them with the final design work. All radio and control system instrumentation should meet or exceed the specifications shown in the quote from Bristoll-Babcock. Final specifications and drawings for all piping, valve, control, and radio systems should be reviewed and certified by a professional engineering firm. Once the system is installed, base personnel should be trained to safely and efficiently operate the radio and control systems. They should also monitor the systems after installation in order to fine tune set points and verify savings. CERL will provide the Heatmap program and Heatmap models of the three lines to IAAP personnel.

Appendix A - Building Description and Steam Consumption

AREA 2

Bldg	Line	Area GSF	Design KBtu/hr	MBtu/ Yr	Base Load KBtu/hr	Slope KBtu/hr-F
Line 3						
2-01	2	39161	2481	6030	354.43	25.93
2-03	2	896		209	23.86	0.00
2-04	2	22506	5804	14106	829.14	60.67
2-05-1	2	21627	1833	4455	261.86	19.16
2-05-2	2	20142	1833	4455	261.86	19.16
2-06-2	2	1440	91	221	13.00	0.95
2-08-1	2	1440	91	221	13.00	0.95
2-08-2	2	1440	91	221	13.00	0.95
2-10	2	28480	2414	5867	344.86	25.23
2-12	2	20467	1552	3772	221.71	16.22
2-13	2	17680	1844	4482	263.43	19.28
2-15	2	5049	19	46	2.71	0.20
2-16-1	2	896		209	23.86	0.00
2-51	2	640		149	17.01	0.00
2-52	2	3821	261	634	37.29	2.73
2-70-1	2	1320		308	35.16	0.00
2-70-2	2	1320		308	35.16	0.00
2-137-1	2	10870	458	1113	65.43	4.79
Totals		199195	18772	46806	2817	196

AREA 3

Bldg	Line	Area GSF	Design KBtu/hr	MBtu/ Yr	Base Load KBtu/hr	Slope KBtu/hr-F
Line 3						
3-01	3	26307	1701	4134	243.00	17.78
3-03	3	896		209	23.86	0.00
3-04	3	24552	5566	13527	795.14	58.18
3-05-1	3	19760	1543	3750	220.43	16.13
3-05-2	3	27012	1580	3840	225.71	16.52
3-06-2	3	1440	91	221	13.00	0.95
3-08-1	3	1440	91	221	13.00	0.95
3-10	3	30005	2358	5731	336.86	24.65
3-12	3	20990	1552	3772	221.71	16.22
3-16-1	3	896		209	23.86	0.00
3-17	3	896		209	23.86	0.00
3-50	3	2653	336	817	48.00	3.51
3-51	3	640		149	17.01	0.00
3-52	3	3821	261	634	37.29	2.73
3-70-1	3	1320		308	35.16	0.00
3-70-2	3	1320		308	35.16	0.00
3-83	3	1260		294	33.56	0.00
3-137-1	3	10093	275	668	39.29	2.87
Totals		175301	15354	39001	2385.89	160.49

AREA 4B-ADMIN

Bldg	Line	Area GSF	Design KBtu/hr	MBtu/ Yr	Base Load KBtu/hr	Slope KBtu/hr-F
Line 4B-Admin						
200-101	4b-Admin	5244	377	916	53.86	3.94
200-131-3	4b-Admin	5055	255	620	36.43	2.67
300-148	4b-Admin	62249	7826	19020	1118.00	81.80
500-37-6	4b-Admin	4048	0	943	174.63	0.00
500-111	4b-Admin	5208	675	1641	96.43	7.06
500-128	4b-Admin	322	0	75	13.89	0.00
500-129	4b-Admin	22302	2486	6042	355.14	25.99
500-129-4	4b-Admin	2845	0	663	122.78	0.00
500-143	4b-Admin	22500	1792	4355	256.00	18.73
500-144	4b-Admin	3280	369	897	52.71	3.86
4-83	4b-Admin	1260	0	294	54.44	0.00
600-84	4b-Admin	5148	330	802	47.14	3.45
100-101	4b-Admin	40744	1812	4404	258.86	18.94
500-118	4b-Admin	17738	645	1568	92.14	6.74
4B-21	4b-Admin	120	0	28	3.20	0.00
4B-22	4b-Admin	20167	2181	5301	311.57	22.80
4B-137-1	4b-Admin	3175	181	440	25.86	1.89
4B-137-2	4b-Admin	2618	181	440	25.86	1.89
4B-137-3	4b-Admin	2618	181	440	25.86	1.89
4B-54	4b-Admin	392	0	91	10.39	0.00
		227033	19291	48980	3135.2	201.6

Appendix B - Heat Loss Coefficients of Steam Pipes and Maximum Steam Flow Rates

PIPE SIZE		1½"	2"	2½"	3"	4"	6"	8"	10"	12"	14"
YEARLY AVG.	AA	94.4	107.9	121.8	138.9	165.7	221.8	274.0	329.2	380.9	413.2
	AAF	45.0	49.4	53.9	59.2	67.6	84.8	100.5	117.1	132.5	142.1
AVG TEMP 51°F	F	48.7	55.8	63.1	72.1	86.4	116.1	143.8	173.1	200.5	217.7
	FF	35.9	40.0	44.1	49.1	56.8	72.7	87.3	102.5	116.8	125.7
JANUARY	AA	102.8	117.5	132.7	151.3	180.5	241.6	298.5	358.6	414.9	450.1
	AAF	49.0	53.8	58.7	64.5	73.6	92.3	109.5	127.5	144.3	154.8
AVG TEMP 22.9°F	F	53.0	60.8	68.8	78.6	94.1	126.5	156.6	188.5	218.4	237.1
	FF	39.1	43.6	48.0	53.5	61.9	79.2	95.1	111.7	127.2	136.9
FEBRUARY	AA	101.5	116.0	131.0	149.3	178.2	238.5	294.7	354.0	409.6	444.3
	AAF	48.4	53.1	57.9	63.7	72.7	91.1	108.1	125.9	142.5	152.8
AVG. TEMP 27.3°F	F	52.3	60.0	67.9	77.6	92.9	124.8	154.6	186.1	215.6	234.1
	FF	38.6	43.0	47.4	52.8	61.1	78.2	93.8	110.3	125.6	135.1
MARCH	AA	98.6	112.8	127.3	145.1	173.2	231.8	286.3	343.9	398.0	431.7
	AAF	47.0	51.6	56.3	61.9	70.6	88.6	105.0	122.3	138.4	148.5
AVG. TEMP 36.9°F	F	50.8	58.3	66.0	75.4	90.2	121.3	150.2	180.8	209.5	227.4
	FF	37.5	41.8	46.1	51.3	59.4	76.0	91.2	107.1	122.0	131.3
APRIL	AA	94.3	107.8	121.7	138.8	165.6	221.6	273.8	328.9	380.6	412.8
	AAF	44.9	49.3	53.8	59.2	67.5	84.7	100.4	117.0	132.4	142.0
AVG. TEMP 51.3°F	F	48.6	55.7	63.1	72.1	86.3	116.0	143.7	172.9	200.3	217.5
	FF	35.9	40.0	44.1	49.1	56.8	72.6	87.2	102.4	116.7	125.6
MAY	AA	91.2	104.2	117.6	134.1	160.1	214.2	264.6	317.9	367.9	399.0
	AAF	43.4	47.7	52.0	57.2	65.3	81.9	97.1	113.1	128.0	137.3
AVG. TEMP. 61.8°F	F	47.0	53.9	61.0	69.7	83.4	112.1	138.7	167.1	193.7	210.2
	FF	34.7	38.6	42.6	47.4	54.9	70.2	84.3	99.0	112.8	121.4
JUNE	AA	88.3	100.9	113.9	129.9	155.0	207.5	256.3	307.9	356.3	386.4
	AAF	42.1	46.2	50.4	55.4	63.2	79.3	94.0	109.5	123.9	132.9
AVG. TEMP 71.4°F	F	45.5	51.2	59.0	67.5	80.8	108.6	134.5	161.9	187.6	203.6
	FF	33.6	37.4	41.3	45.9	53.2	68.0	81.6	95.9	109.2	117.5
JULY	AA	87.0	98.4	110.4	128.1	152.9	204.7	252.8	303.7	351.4	381.2
	AAF	41.5	45.6	49.7	54.7	62.4	78.2	92.7	108.0	122.2	131.1
AVG TEMP 75.4°F	F	44.9	51.5	58.2	66.6	79.7	107.1	132.7	159.7	185.0	200.8
	FF	33.1	36.9	40.7	45.3	52.4	67.1	80.5	94.6	107.8	115.9
AUGUST	AA	87.5	100.1	113.0	128.8	153.7	205.7	254.1	305.3	353.2	383.2
	AAF	41.7	45.8	49.9	54.9	62.7	78.6	93.2	108.6	122.9	131.8
AVG TEMP 73.9°F	F	45.1	51.7	58.5	66.9	80.1	107.7	133.3	160.5	186.0	201.9
	FF	33.3	37.1	40.9	45.5	52.7	67.4	80.9	95.1	108.3	116.5
SEPTEMBER	AA	90.1	103.0	116.3	132.5	158.2	211.7	261.5	314.1	363.5	394.3
	AAF	42.9	47.1	51.4	56.5	64.5	80.9	95.9	111.7	126.5	135.6
AVG TEMP 65.4°F	F	46.4	53.2	60.2	68.9	82.4	110.8	137.2	165.2	191.4	207.7
	FF	34.3	38.2	42.1	46.9	54.2	69.4	83.3	97.9	111.5	119.9
OCTOBER	AA	93.1	106.4	120.2	137.0	163.5	218.8	270.3	324.7	375.7	407.6
	AAF	44.4	48.7	53.1	58.4	66.7	83.6	99.2	115.5	130.7	140.2
AVG TEMP 55.3°F	F	48.0	55.0	62.3	71.2	85.2	114.5	141.8	170.7	197.8	214.7
	FF	35.4	39.4	43.5	48.4	56.1	71.7	86.1	101.1	115.2	124.0
NOVEMBER	AA	97.8	111.8	126.2	143.8	171.6	229.7	283.8	340.9	394.5	427.9
	AAF	46.6	51.1	55.8	61.4	70.0	87.8	104.1	121.2	137.2	147.2
AVG TEMP 39.8°F	F	50.4	57.8	65.4	74.7	89.4	120.2	148.9	179.2	207.7	225.4
	FF	37.2	41.4	45.7	50.8	58.9	75.3	90.4	106.2	121.0	130.1
DECEMBER	AA	101.4	115.9	130.9	149.2	178.1	238.3	294.4	353.6	409.2	443.9
	AAF	48.3	53.1	57.9	63.6	72.6	91.1	108.0	125.8	142.4	152.7
AVG TEMP 27.6°F	F	52.3	59.9	67.8	77.5	92.8	124.7	154.5	185.9	215.4	233.9
	FF	38.6	43.0	47.4	52.7	61.1	78.1	93.7	110.2	125.5	135.0

FROM R.H. TIEMEIER

INSULATION (AA) 2" LAMINATED CORRUGATED ASBESTOS + 3/32" ASPHALT PAPER JACKET

AAF 2" LAMINATED CORRUGATED ASBESTOS + 3/32 ASPHALT PAPER + 2" FIBERGLASS

8" TO 900 (F) 2" FIBERGLASS

FF 2" FIBERGLASS + 2" FIBERGLASS

IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA
OPERATED BY
MORRISON & KNUDSEN CO., INC.
MORRISON & MANGER
DES MOINES, IOWA

DE JAL
DRAWN JAL
APPROVAL

REV. BY DATE DESCRIPTION APPROVAL DATE

HEAT LOSS ON OVERHEAD STEAM MAINS IN BTU/HR/L.F.

150 PSI S.P.

E.O. NO.
W.O. NO.
DATE 5-11-78
SHEET NO.

From: ENSRML --4381
To: ENSRML --4381

Date and time 09/08/93 12:54:20

From: Dick Luttenegger
Subject: STEAN FLOWS & PRESSURES

SUMMER:

	LBS PER HOUR	
LINE 1 MAIN	40,000	PEAK
LINE 1 USE	15,000	(CELL AREA - 8,000 (1-18 AREA - 7,000
LINE 2 USE	10,000	
LINE 3 USE	10,000	
LINE 9 USE	3,000	
LINE 4B USE	2,000	60 PSI
WINTER	150,000	PEAK
LINE 1 USE	50,000	(CELL AREA - 20,000 70 PSI (1-18 AERA - 15,000 50 PSI (REMAINDER OF LINE 1 - 15,000
LINE 2 USE	25,000	60 PSI
LINE 3 USE	30,000	60 PSI
LINE 4B USE	10,000	60 PSI
LINE 9 USE	8,000	
ADM & SHOPS USE	20,000	
ROUNDHOUSE USE	3,000	30 PSI
OTHER - LAUNDRY & LINE 8	4,000	

AREAS REQUIRING 60 PSI STEAM CAN BE CONVERTED TO 15 PSI WATER HEATERS.

ALL AREAS NOT INDICATED OTHERWISE ARE 15 PSI.

120,000 STEAM OUT PEAK IN JAN 94
PER HARRY TATE 2-15-94

Appendix C - SHDP Input and Output Files

Line 2 Input File

SYSTEM VARIABLES AND EXECUTION CONTROLS

FLOW TOLERANCE = 10.00 lbm/hr
UNKNOWN PARAMETER TOLERANCE = .000500
UNKNOWN PRESSURE TOLERANCE = .000050
UNKNOWN NODE FLOW TOLERANCE = 1.000 lbm/hr
PC = 20 1 5 20 1 4 4 0 0 0
UNS = 1 2 2 2 4 3 1 1 2 2

PIPE DESCRIPTION SECTION

NCE NUM	FROM NODE	TO NODE	STATUS	DIAMETER (in)	LENGTH (ft)		RELATIVE ROUGHNESS	HEAT LOSS COEF (Btu/hr-ft-F)	TEMP (F)
1	2	A		8.1	1466.+	0.	.312E-3	1.16	65.0
2	A	B		8.1	316.+	0.	.312E-3	1.16	65.0
3	B	C		8.1	374.+	0.	.312E-3	1.16	65.0
4	C	D		8.1	518.+	0.	.312E-3	1.16	65.0
5	D	E		6.1	748.+	0.	.412E-3	.98	65.0
6	E	F		6.1	402.+	0.	.412E-3	.98	65.0
7	F	G		4.0	288.+	0.	.620E-3	.78	65.0
8	B	201A		2.1	50.+	0.	.121E-2	.57	65.0
9	G	H		3.1	288.+	0.	.814E-3	.68	65.0
10	H	I		3.1	345.+	0.	.814E-3	.68	65.0
11	I	K		2.1	259.+	0.	.121E-2	.57	65.0
12	K	213A		2.1	115.+	0.	.121E-2	.57	65.0
13	K	215A		2.1	1150.+	0.	.121E-2	.57	65.0
14	I	212A		3.1	1150.+	0.	.814E-3	.68	65.0
15	A	252A		1.6	115.+	0.	.144E-2	.52	65.0
16	E	52A		2.1	50.+	0.	.121E-2	.57	65.0
17	G	51A		2.1	50.+	0.	.121E-2	.57	65.0
18	H	137A		2.1	748.+	0.	.121E-2	.57	65.0
19	C	251A		1.3	115.+	0.	.166E-2	.46	65.0
20	C	204A		4.0	10.+	0.	.620E-3	.78	65.0
21	D	203A		1.3	25.+	0.	.166E-2	.46	65.0
22	G	701A		1.3	50.+	0.	.166E-2	.46	65.0
23	E	702A		1.3	50.+	0.	.166E-2	.46	65.0

REGULATOR AND VALVE DESCRIPTION SECTION

NCE NUM	FROM NODE	TO NODE	STATUS	SIZING COEFFICIENT	CONFIGURATION CONSTANT	MINIMUM PRESSURE DROP
24	201A	201	UNKNOWN	3.00	35.00	.0
25	203A	203	UNKNOWN	3.00	35.00	.0
26	204A	204	UNKNOWN	3.00	35.00	.0
27	51A	51	UNKNOWN	3.00	35.00	.0
28	52A	52	UNKNOWN	3.00	35.00	.0
29	212A	212	UNKNOWN	3.00	35.00	.0
30	215A	215	UNKNOWN	3.00	35.00	.0
31	213A	213	UNKNOWN	3.00	35.00	.0
32	251A	251	UNKNOWN	3.00	35.00	.0
33	252A	252	UNKNOWN	3.00	35.00	.0
34	701A	701	UNKNOWN	3.00	35.00	.0
35	702A	702	UNKNOWN	3.00	35.00	.0
36	137A	137	UNKNOWN	3.00	35.00	.0

TRAP INPUT DATA

5.0 percent trap leakage

VAULT INPUT DATA

VAULT NUMBER	NODE NAME	MAIN PIPE DIAMETER (in)	MAIN PIPE LENGTH (ft)	HEAT TRANSFER COEFFICIENT (Btu/hr-ft-F)	ENVIROMENT TEMPERATURE (F)

NODE INPUT DATA

NODE NAME	PRESSURE (psig)	NODE FLOW (lbm/hr)	NODE FLOW RETURNED	PIPE CONDS RETURNED	LOAD CONDS TEMPERATURE
2	155.00?	30000.?	.00	.00	150.0
A	150.00?	0.	.00	.00	150.0
B	150.00?	0.	.00	.00	150.0
C	150.00?	0.	.00	.00	150.0
D	150.00?	0.	.00	.00	150.0
E	150.00?	0.	.00	.00	150.0
F	150.00?	0.	.00	.00	150.0
G	150.00?	0.	.00	.00	150.0
H	150.00?	0.	.00	.00	150.0
I	150.00?	0.	.00	.00	150.0
K	150.00?	0.	.00	.00	150.0
201A	150.00?	0.	.00	.00	150.0
201	60.00	-354.	.00	.00	150.0
203A	150.00?	0.	.00	.00	150.0
203	60.00	-24.	.00	.00	150.0
204	60.00	-829.	.00	.00	150.0
204A	150.00?	0.	.00	.00	150.0
51	60.00	-262.	.00	.00	150.0
51A	150.00?	0.	.00	.00	150.0
52	60.00	-262.	.00	.00	150.0
52A	150.00?	0.	.00	.00	150.0
212	60.00	-222.	.00	.00	150.0
212A	150.00?	0.	.00	.00	150.0
213	60.00	-263.	.00	.00	150.0
213A	75.00	0.	.00	.00	150.0
215	60.00	-3.	.00	.00	150.0
215A	150.00?	0.	.00	.00	150.0
251	60.00	-17.	.00	.00	150.0
251A	150.00?	0.	.00	.00	150.0
252	60.00	-37.	.00	.00	150.0
252A	150.00?	0.	.00	.00	150.0
701	60.00	-35.	.00	.00	150.0
701A	150.00?	0.	.00	.00	150.0
702	60.00	-35.	.00	.00	150.0
702A	150.00?	0.	.00	.00	150.0
137	60.00	-65.	.00	.00	150.0
137A	150.00?	0.	.00	.00	150.0

NODE CORRESPONDENCE TABLE AND LIST OF ADJACENT NODES

NODE NUMBER	NODE NAME	ADJACENT NODES(BY NAME)			
1	2	A			
2	A	B	252A	2	
3	B	C	201A	A	
4	C	D	251A	204A	B
5	D	E	203A	C	
6	E	F	52A	702A	D
7	F	G	E		
8	G	H	51A	701A	F
9	H	I	137A	G	
10	I	K	212A	H	
11	K	213A	215A	I	
12	201A	201	B		
13	201	201A			
14	203A	203	D		
15	203	203A			
16	204	204A			
17	204A	204	C		
18	51	51A			
19	51A	51	G		
20	52	52A			
21	52A	52	E		
22	212	212A			
23	212A	212	I		
24	213	213A			
25	213A	213	K		
26	215	215A			
27	215A	215	K		
28	251	251A			
29	251A	251	C		
30	252	252A			
31	252A	252	A		
32	701	701A			
33	701A	701	G		
34	702	702A			
35	702A	702	E		
36	137	137A			
37	137A	137	H		

***** PROBLEM SUMMARY *****
37 NODES IN THE SYSTEM
23 PIPES IN THE SYSTEM
13 VALVES OR REGULATORS
5 PERCENT TRAP LEAKAGE
0 VAULTS IN THE SYSTEM
13 UNKNOWN PARAMETERS
23 UNKNOWN PRESSURES
1 UNKNOWN FLOWS

03/03/94 13:42:32
iaap265

Iowa Army Ammunition Plant
Line 2 - 65 degrees F High Pressure

SOLUTION COMPLETED IN 8 ITERATIONS
SOME NODES MAY NOT BE BALANCED

*** PROBLEM SUMMARY ***
37 NODES IN THE SYSTEM
23 PIPES IN THE SYSTEM
13 VALVES OR REGULATORS
5 PERCENT TRAP LEAKAGE
0 VAULTS IN THE SYSTEM
13 UNKNOWN PARAMETERS
23 UNKNOWN PRESSURES
1 UNKNOWN FLOWS

COMPUTED NODE DATA

NODE NAME	PRESSURE (psig)	NODE FLOW (lbm/hr)	CONDS FLOW (lbm/hr)	FLOW LOSS (Btu/hr)	CONDS LOSS (Btu/hr)	TEMP (F)	RESIDUAL (lbm/hr)
2	155.00	5215.5?	-301.6	.0	102859.6	368.3	-.03
A	154.83?	.0	-377.2	.0	128613.5	368.2	1.02
B	154.80?	.0	-147.0	.0	50114.3	368.2	.26
C	154.78?	.0	-194.2	.0	66224.2	368.2	.42
D	154.76?	.0	-238.5	.0	81325.4	368.2	-2.14
E	154.65?	.0	-208.9	.0	71215.6	368.1	1.11
F	154.62?	.0	-109.6	.0	37369.0	368.1	-.62
G	154.44?	.0	-83.6	.0	28479.0	368.0	1.13
H	154.00?	.0	-151.6	.0	51633.9	367.8	-.21
I	153.67?	.0	-205.9	.0	70087.5	367.6	.16
K	153.18?	.0	-153.5	.0	52211.3	367.4	-16.05
201A	154.76?	.0	-5.1	.0	1722.8	368.2	-.11
201	60.00	-354.4	.0	41482.0	.0	307.3	.00
203A	154.75?	.0	-2.0	.0	695.2	368.2	.04
203	60.00	-23.9	.0	2797.5	.0	307.3	.00
204	60.00	-829.1	.0	97045.0	.0	307.3	.00
204A	154.77?	.0	-1.4	.0	471.6	368.2	-.54
51	60.00	-261.9	.0	30655.0	.0	307.3	.00
51A	154.41?	.0	-5.0	.0	1720.8	368.0	.14
52	60.00	-261.9	.0	30655.0	.0	307.3	.00
52A	154.63?	.0	-5.1	.0	1722.1	368.1	-.03
212	60.00	-221.7	.0	25949.7	.0	307.3	.00
212A	153.54?	.0	-138.3	.0	47074.0	367.6	-.31
213	60.00	-263.4	.0	30830.6	.0	307.3	.04
213A	153.12?	.0	-11.6	.0	3939.5	367.4	16.02
215	60.00	-2.7	.0	316.0	.0	307.3	.00
215A	153.04?	.0	-115.8	.0	39390.2	367.3	-.17
251	60.00	-17.0	.0	1989.8	.0	307.3	.00
251A	154.76?	.0	-9.4	.0	3198.1	368.2	.00
252	60.00	-37.3	.0	4365.9	.0	307.3	.00
252A	154.82?	.0	-10.6	.0	3616.0	368.2	-.03
701	60.00	-35.2	.0	4120.1	.0	307.3	.00
701A	154.43?	.0	-4.1	.0	1388.8	368.0	.02
702	60.00	-35.2	.0	4120.1	.0	307.3	.00
702A	154.64?	.0	-4.1	.0	1389.9	368.1	.02
137	60.00	-65.4	.0	7655.0	.0	307.3	.00
137A	153.88?	.0	-75.5	.0	25697.4	367.7	-.15

COMPUTED PIPE FLOWS AND PARAMETERS

FROM NODE	TO NODE	STATUS	FLOW (lbm/hr)	CONDENSATE (lbm/hr)	HEAT LOSS (Btu/hr)	DIAMETER (in)	RE NUMBER	FRIC FACTOR
2	A		4905.6	603.19	515682.3	8.07	1.88E+5	1.80E-2
A	B		4459.2	130.00	111139.5	8.07	1.71E+5	1.81E-2
B	C		3932.3	153.86	131532.5	8.07	1.51E+5	1.84E-2
C	D		2849.1	213.10	182169.0	8.07	1.09E+5	1.92E-2
D	E		2566.4	259.91	222214.2	6.07	1.31E+5	1.93E-2
E	F		2017.9	139.67	119412.2	6.07	1.03E+5	1.99E-2
F	G		1900.6	79.59	68078.6	4.03	1.46E+5	2.02E-2
B	201A		371.3	10.11	8640.6	2.07	5.56E+4	2.46E-2
G	H		1477.2	69.30	59321.7	3.07	1.49E+5	2.11E-2
H	I		1164.9	82.99	71019.1	3.07	1.18E+5	2.15E-2
I	K		578.9	52.18	44662.1	2.07	8.66E+4	2.36E-2
K	213A		303.0	23.17	19822.0	2.07	4.53E+4	2.43E-2
K	215A		130.3	231.67	198208.6	2.07	1.95E+4	2.87E-2
I	212A		371.7	276.66	236643.3	3.07	3.75E+4	2.47E-2
A	252A		59.9	21.21	18131.4	1.57	1.18E+4	3.21E-2
E	52A		278.9	10.10	8638.6	2.07	4.17E+4	2.55E-2
G	51A		279.1	10.10	8635.7	2.07	4.18E+4	2.55E-2
H	137A		152.7	150.95	129091.7	2.07	2.29E+4	2.79E-2
C	251A		38.4	18.76	16037.8	1.31	9.08E+3	3.42E-2
C	204A		841.9	2.77	2364.8	4.03	6.47E+4	2.22E-2
D	203A		38.0	4.08	3486.4	1.31	8.98E+3	3.44E-2
G	701A		51.3	8.15	6969.3	1.31	1.21E+4	3.23E-2
E	702A		51.3	8.15	6971.6	1.31	1.21E+4	3.23E-2

COMPUTED VALVE AND REGULATOR FLOWS AND PARAMETERS

FROM NODE	TO NODE	STATUS	FLOW (lbm/hr)	Cs
201A	201	?	358.1	2.2
203A	203	?	27.6	.2
204A	204	?	832.8	5.1
51A	51	?	265.6	1.6
52A	52	?	265.6	1.6
212A	212	?	225.4	1.4
215A	215	?	6.4	.0
213A	213	?	267.2	1.7
251A	251	?	20.7	.1
252A	252	?	41.0	.3
701A	701	?	38.9	.2
702A	702	?	38.9	.2
137A	137	?	69.1	.4

COMPUTED TRAP LOSSES

5 percent trap leakage rate

Trap Steam Losses	Trap Heat Losses
246.7 lbs/hr	294335.4 Btus/hr

SYSTEM MASS FLOWS

(1)	Steam to loads:	2409. lbm/hr
(2)	Steam condensed in pipes:	2560. lbm/hr
(3)	Steam condensed in vaults:	0. lbm/hr
(4)	Steam lost to trap leakage:	247. lbm/hr
(5)	Total steam plant output:	5215. lbm/hr
(6)	Pipe and vault condensate returned:	0. lbm/hr
(7)	Load condensate returned:	0. lbm/hr
(8)	Total condensate returned:	0. lbm/hr

SYSTEM HEAT LOSSES AND DISTRIBUTION EFFICIENCY
(M = Million)

(1)	Total pipe conduction heat losses:	2.189 MBtus/hr	60.18 %
(2)	Total pipe condensate heat losses:	.872 MBtus/hr	23.98 %
(3)	Total load condensate heat losses:	.282 MBtus/hr	7.75 %
(4)	Total vault conduction heat losses:	.000 MBtus/hr	.00 %
(5)	Total vault condensate heat losses:	.000 MBtus/hr	.00 %
(6)	Total trap heat losses:	.294 MBtus/hr	8.09 %
(7)	Total heat losses:	3.637 MBtus/hr	100.00 %
(8)	Total heat to loads:	2.566 MBtus/hr	
(9)	Total heat input to supply:	6.237 MBtus/hr	
(10)	Total heat returned to plant:	.000 MBtus/hr	
(11)	Net heat input from plant:	6.237 MBtus/hr	

DISTRIBUTION EFFICIENCY: 41.7% [1.0-(7)/(11)]

Line 3 Input File

SYSTEM VARIABLES AND EXECUTION CONTROLS

FLOW TOLERANCE = 10.00 lbm/hr
UNKNOWN PARAMETER TOLERANCE = .000500
UNKNOWN PRESSURE TOLERANCE = .000050
UNKNOWN NODE FLOW TOLERANCE = 1.000 lbm/hr
PC = 20 1 5 20 1 4 4 0 0 0
UNS = 1 2 2 2 4 3 1 1 2 2

PIPE DESCRIPTION SECTION

NCE NUM	FROM NODE	TO NODE	STATUS	DIAMETER (in)	LENGTH (ft)	RELATIVE ROUGHNESS	HEAT LOSS COEF (Btu/hr-ft-F)	TEMP (F)
1	A	B		6.1	863.+ 0.	.412E-3	.98	65.0
2	B	C		6.1	115.+ 0.	.412E-3	.98	65.0
3	C	D		6.1	345.+ 0.	.412E-3	.98	65.0
4	D	E		6.1	173.+ 0.	.412E-3	.98	65.0
5	E	F		6.1	460.+ 0.	.412E-3	.98	65.0
6	F	G		6.1	345.+ 0.	.412E-3	.98	65.0
7	D	301A		4.0	10.+ 0.	.620E-3	.78	65.0
8	G	H		4.0	460.+ 0.	.620E-3	.78	65.0
9	H	I		4.0	288.+ 0.	.620E-3	.78	65.0
10	I	J		4.0	288.+ 0.	.620E-3	.78	65.0
11	J	K		4.0	75.+ 0.	.620E-3	.78	65.0
12	K	L		3.1	345.+ 0.	.814E-3	.68	65.0
13	L	M		3.1	489.+ 0.	.814E-3	.68	65.0
14	M	N		3.1	518.+ 0.	.814E-3	.68	65.0
15	N	312A		3.1	633.+ 0.	.814E-3	.68	65.0
16	C	352A		2.1	115.+ 0.	.121E-2	.57	65.0
17	H	52A		2.1	75.+ 0.	.121E-2	.57	65.0
18	K	51A		2.1	50.+ 0.	.121E-2	.57	65.0
19	M	310A		2.1	50.+ 0.	.121E-2	.57	65.0
20	L	137A		2.1	748.+ 0.	.121E-2	.57	65.0
21	I	O		2.1	575.+ 0.	.121E-2	.57	65.0
22	B	383A		1.3	50.+ 0.	.166E-2	.46	65.0
23	E	351A		1.3	75.+ 0.	.166E-2	.46	65.0
24	F	304A		4.0	10.+ 0.	.620E-3	.78	65.0
25	F	303A		1.3	50.+ 0.	.166E-2	.46	65.0
26	H	702A		1.3	25.+ 0.	.166E-2	.46	65.0
27	J	701A		1.3	144.+ 0.	.166E-2	.46	65.0
28	N	161A		1.3	230.+ 0.	.166E-2	.46	65.0
29	N	317A		1.3	460.+ 0.	.164E-2	.46	65.0
30	O	350A		1.3	10.+ 0.	.166E-2	.46	65.0
31	O	81A		1.3	403.+ 0.	.166E-2	.46	65.0
32	O	62A		1.3	775.+ 0.	.166E-2	.46	65.0

NCE NUM	FROM NODE	TO NODE	STATUS	SIZING COEFFICIENT	CONFIGURATION CONSTANT	MINIMUM PRESSURE DROP
33	301A	301	UNKNOWN	3.00	35.00	.0
34	303A	303	UNKNOWN	3.00	35.00	.0
35	304A	304	UNKNOWN	3.00	35.00	.0
36	51A	51	UNKNOWN	3.00	35.00	.0
37	52A	52	UNKNOWN	3.00	35.00	.0
38	62A	62	UNKNOWN	3.00	35.00	.0
39	81A	81	UNKNOWN	3.00	35.00	.0
40	310A	310	UNKNOWN	3.00	35.00	.0
41	312A	312	UNKNOWN	3.00	35.00	.0
42	161A	161	UNKNOWN	3.00	35.00	.0
43	317A	317	UNKNOWN	3.00	35.00	.0
44	350A	350	UNKNOWN	3.00	35.00	.0
45	351A	351	UNKNOWN	3.00	35.00	.0
46	352A	352	UNKNOWN	3.00	35.00	.0
47	701A	701	UNKNOWN	3.00	35.00	.0
48	702A	702	UNKNOWN	3.00	35.00	.0
49	383A	383	UNKNOWN	3.00	35.00	.0
50	137A	137	UNKNOWN	3.00	35.00	.0

TRAP INPUT DATA

5.0 percent trap leakage

VAULT INPUT DATA

VAULT NUMBER	NODE NAME	MAIN PIPE DIAMETER (in)	MAIN PIPE LENGTH (ft)	HEAT TRANSFER COEFFICIENT (Btu/hr-ft-F)	ENVIROMENT TEMPERATURE (F)

NODE NAME	PRESSURE (psig)	NODE FLOW (lbm/hr)	NODE FLOW RETURNED	PIPE CONDS RETURNED	LOAD CONDS TEMPERATURE
A	155.00?	30000.?	.00	.00	150.0
B	150.00?	0.	.00	.00	150.0
C	150.00?	0.	.00	.00	150.0
D	150.00?	0.	.00	.00	150.0
E	150.00?	0.	.00	.00	150.0
F	150.00?	0.	.00	.00	150.0
G	150.00?	0.	.00	.00	150.0
H	150.00?	0.	.00	.00	150.0
I	150.00?	0.	.00	.00	150.0
J	150.00?	0.	.00	.00	150.0
K	150.00?	0.	.00	.00	150.0
L	150.00?	0.	.00	.00	150.0
M	150.00?	0.	.00	.00	150.0
N	150.00?	0.	.00	.00	150.0
O	150.00?	0.	.00	.00	150.0
301A	150.00?	0.	.00	.00	150.0
301	60.00	-343.	.00	.00	150.0
303A	150.00?	0.	.00	.00	150.0
303	60.00	-24.	.00	.00	150.0
304	60.00	-795.	.00	.00	150.0
304A	150.00?	0.	.00	.00	150.0
51	60.00	-220.	.00	.00	150.0
51A	150.00?	0.	.00	.00	150.0
52	60.00	-226.	.00	.00	150.0
52A	150.00?	0.	.00	.00	150.0
62	60.00	-13.	.00	.00	150.0
62A	150.00?	0.	.00	.00	150.0
81	60.00	-13.	.00	.00	150.0
81A	150.00?	0.	.00	.00	150.0
310	60.00	-337.	.00	.00	150.0
310A	150.00?	0.	.00	.00	150.0
312	60.00	-222.	.00	.00	150.0
312A	75.00	0.	.00	.00	150.0
161	60.00	-24.	.00	.00	150.0
161A	150.00?	0.	.00	.00	150.0
317	60.00	-24.	.00	.00	150.0
317A	150.00?	0.	.00	.00	150.0
350	60.00	-48.	.00	.00	150.0
350A	150.00?	0.	.00	.00	150.0
351	60.00	-17.	.00	.00	150.0
351A	150.00?	0.	.00	.00	150.0
352	60.00	-37.	.00	.00	150.0
352A	150.00?	0.	.00	.00	150.0
701	60.00	-35.	.00	.00	150.0
701A	150.00?	0.	.00	.00	150.0
702	60.00	-35.	.00	.00	150.0
702A	150.00?	0.	.00	.00	150.0
383	60.00	-34.	.00	.00	150.0
383A	150.00?	0.	.00	.00	150.0
137	60.00	-39.	.00	.00	150.0
137A	150.00?	0.	.00	.00	150.0

NODE CORRESPONDENCE TABLE AND LIST OF ADJACENT NODES

NODE NUMBER	NODE NAME	ADJACENT NODES (BY NAME)			
1	A	B			
2	B	C	383A	A	
3	C	D	352A	B	
4	D	E	301A	C	
5	E	F	351A	D	
6	F	G	304A	303A	E
7	G	H	F		
8	H	I	52A	702A	G
9	I	J	O	H	
10	J	K	701A	I	
11	K	L	51A	J	
12	L	M	137A	K	
13	M	N	310A	L	
14	N	312A	161A	317A	M
15	O	350A	81A	62A	I
16	301A	301	D		
17	301	301A			
18	303A	303	F		
19	303	303A			
20	304	304A			
21	304A	304	F		
22	51	51A			
23	51A	51	K		
24	52	52A			
25	52A	52	H		
26	62	62A			
27	62A	62	O		
28	81	81A			
29	81A	81	O		
30	310	310A			
31	310A	310	M		
32	312	312A			
33	312A	312	N		
34	161	161A			
35	161A	161	N		
36	317	317A			
37	317A	317	N		
38	350	350A			
39	350A	350	O		
40	351	351A			
41	351A	351	E		
42	352	352A			
43	352A	352	C		
44	701	701A			
45	701A	701	J		
46	702	702A			
47	702A	702	H		
48	383	383A			
49	383A	383	B		
50	137	137A			
51	137A	137	L		

***** PROBLEM SUMMARY *****
51 NODES IN THE SYSTEM
32 PIPES IN THE SYSTEM
18 VALVES OR REGULATORS
5 PERCENT TRAP LEAKAGE
0 VAULTS IN THE SYSTEM
18 UNKNOWN PARAMETERS
32 UNKNOWN PRESSURES
1 UNKNOWN FLOWS

03/03/94 14:22:15
iaap3

Iowa Army Ammunition Plant
Line 3 - 65 degrees F High Pressure

SOLUTION COMPLETED IN 7 ITERATIONS

*** PROBLEM SUMMARY ***
51 NODES IN THE SYSTEM
32 PIPES IN THE SYSTEM
18 VALVES OR REGULATORS
5 PERCENT TRAP LEAKAGE
0 VAULTS IN THE SYSTEM
18 UNKNOWN PARAMETERS
32 UNKNOWN PRESSURES
1 UNKNOWN FLOWS

COMPUTED NODE DATA

NODE NAME	PRESSURE (psig)	NODE FLOW (lbm/hr)	CONDS FLOW (lbm/hr)	FLOW LOSS (Btu/hr)	CONDS LOSS (Btu/hr)	TEMP (F)	RESIDUAL (lbm/hr)
A	155.00	5096.4?	-149.9	.0	51110.4	368.3	-.90
B	154.58?	.0	-173.9	.0	59272.8	368.1	1.32
C	154.53?	.0	-91.5	.0	31172.1	368.1	.61
D	154.39?	.0	-91.3	.0	31106.4	368.0	-9.67
E	154.33?	.0	-116.0	.0	39509.9	368.0	-.08
F	154.19?	.0	-145.1	.0	49443.0	367.9	-1.93
G	154.13?	.0	-123.3	.0	41988.6	367.9	.89
H	153.53?	.0	-112.7	.0	38347.3	367.6	-.14
I	153.25?	.0	-137.3	.0	46691.4	367.4	.25
J	153.08?	.0	-61.7	.0	20989.9	367.4	.19
K	153.04?	.0	-56.8	.0	19300.3	367.3	-.31
L	152.54?	.0	-175.3	.0	59555.0	367.1	.21
M	152.09?	.0	-125.8	.0	42701.5	366.9	.06
N	151.93?	.0	-193.9	.0	65829.3	366.8	.05
O	152.79?	.0	-154.4	.0	52471.9	367.2	.08
301A	154.39?	.0	-1.4	.0	470.9	368.0	9.04
301	60.00	-343.0	.0	40147.7	.0	307.3	.00
303A	154.18?	.0	-4.1	.0	1387.6	367.9	.02
303	60.00	-23.9	.0	2797.5	.0	307.3	.00
304	60.00	-795.1	.0	93065.3	.0	307.3	.00
304A	154.19?	.0	-1.4	.0	470.6	367.9	1.29
51	60.00	-220.4	.0	25797.5	.0	307.3	.00
51A	153.02?	.0	-5.0	.0	1712.2	367.3	.02
52	60.00	-225.7	.0	26417.9	.0	307.3	.00
52A	153.50?	.0	-7.6	.0	2572.8	367.6	-.06
62	60.00	-13.0	.0	1521.6	.0	307.3	.00
62A	152.38?	.0	-62.9	.0	21375.9	367.0	-.10
81	60.00	-13.0	.0	1521.6	.0	307.3	.00
81A	152.69?	.0	-32.7	.0	11125.4	367.2	-.07
310	60.00	-336.9	.0	39433.7	.0	307.3	.00
310A	152.05?	.0	-5.0	.0	1706.2	366.9	-.08
312	60.00	-221.7	.0	25949.7	.0	307.3	.00
312A	151.88?	.0	-75.9	.0	25755.5	366.8	-.23
161	60.00	-23.9	.0	2797.5	.0	307.3	.00
161A	151.88?	.0	-18.6	.0	6330.6	366.8	-.06
317	60.00	-23.9	.0	2797.5	.0	307.3	.00
317A	151.75?	.0	-37.3	.0	12656.7	366.7	-.09
350	60.00	-48.0	.0	5618.3	.0	307.3	.00
350A	152.79?	.0	-.8	.0	276.1	367.2	-.11
351	60.00	-17.1	.0	2001.5	.0	307.3	.00
351A	154.32?	.0	-6.1	.0	2082.5	368.0	-.03
352	60.00	-37.3	.0	4365.9	.0	307.3	.00
352A	154.53?	.0	-11.6	.0	3959.6	368.1	-.04
701	60.00	-35.2	.0	4120.1	.0	307.3	.00
701A	153.04?	.0	-11.7	.0	3980.1	367.3	-.05
702	60.00	-35.2	.0	4120.1	.0	307.3	.00
702A	153.52?	.0	-2.0	.0	692.2	367.6	.00
383	60.00	-33.6	.0	3932.8	.0	307.3	.00
383A	154.57?	.0	-4.1	.0	1389.6	368.1	.02
137	60.00	-39.3	.0	4600.0	.0	307.3	.00
137A	152.45?	.0	-75.2	.0	25565.4	367.1	-.15

COMPUTED PIPE FLOWS AND PARAMETERS

FROM NODE	TO NODE	STATUS	FLOW (lbm/hr)	CONDENSATE (lbm/hr)	HEAT LOSS (Btu/hr)	DIAMETER (in)	RE NUMBER	FRIC FACTOR
A	B		4939.2	299.72	256413.9	6.07	2.52E+5	1.82E-2
B	C		4706.0	39.93	34156.1	6.07	2.40E+5	1.82E-2
C	D		4544.8	119.76	102452.8	6.07	2.32E+5	1.83E-2
D	E		4089.5	60.05	51366.8	6.07	2.09E+5	1.84E-2
E	F		3930.1	159.65	136560.4	6.07	2.01E+5	1.85E-2
F	G		2929.0	119.74	102403.7	6.07	1.49E+5	1.90E-2
D	301A		365.4	2.76	2363.3	4.03	2.81E+4	2.56E-2
G	H		2796.5	126.81	108616.5	4.03	2.15E+5	1.97E-2
H	I		2381.4	79.37	67956.1	4.03	1.83E+5	1.99E-2
I	J		1867.2	79.37	67931.8	4.03	1.44E+5	2.03E-2
J	K		1738.3	20.67	17687.6	4.03	1.34E+5	2.04E-2
K	L		1436.3	82.78	70901.2	3.07	1.45E+5	2.12E-2
L	M		1126.3	117.26	100418.6	3.07	1.14E+5	2.16E-2
M	N		638.6	124.19	106322.1	3.07	6.44E+4	2.29E-2
N	312A		309.2	151.75	129904.2	3.07	3.12E+4	2.55E-2
C	352A		60.9	23.24	19865.5	2.07	9.11E+3	3.36E-2
H	52A		245.1	15.12	12934.9	2.07	3.67E+4	2.59E-2
K	51A		237.4	10.07	8616.6	2.07	3.55E+4	2.61E-2
M	310A		353.7	10.05	8603.5	2.07	5.29E+4	2.48E-2
L	137A		126.3	150.49	128795.1	2.07	1.89E+4	2.89E-2
I	O		368.5	115.79	99090.1	2.07	5.52E+4	2.47E-2
B	383A		49.7	8.15	6970.9	1.31	1.18E+4	3.25E-2
E	351A		35.2	12.22	10452.2	1.31	8.32E+3	3.49E-2
F	304A		809.8	2.76	2362.6	4.03	6.22E+4	2.23E-2
F	303A		40.0	8.15	6966.5	1.31	9.45E+3	3.40E-2
H	702A		49.2	4.07	3479.6	1.31	1.16E+4	3.26E-2
J	701A		58.8	23.41	20027.8	1.31	1.39E+4	3.14E-2
N	161A		54.4	37.30	31929.8	1.31	1.29E+4	3.19E-2
N	317A		73.0	74.58	63853.3	1.31	1.73E+4	3.02E-2
O	350A		60.6	1.62	1390.2	1.31	1.43E+4	3.13E-2
O	81A		57.6	65.47	56021.8	1.31	1.36E+4	3.15E-2
O	62A		87.7	125.85	107707.4	1.31	2.07E+4	2.93E-2

COMPUTED VALVE AND REGULATOR FLOWS AND PARAMETERS

FROM NODE	TO NODE	STATUS	FLOW (lbm/hr)	Cs
301A	301	?	346.7	2.1
303A	303	?	27.6	.2
304A	304	?	798.8	4.9
51A	51	?	224.1	1.4
52A	52	?	229.4	1.4
62A	62	?	16.7	.1
81A	81	?	16.7	.1
310A	310	?	340.6	2.1
312A	312	?	225.4	1.4
161A	161	?	27.6	.2
317A	317	?	27.6	.2
350A	350	?	51.7	.3
351A	351	?	20.8	.1
352A	352	?	41.0	.3
701A	701	?	38.9	.2
702A	702	?	38.9	.2
383A	383	?	37.3	.2
137A	137	?	43.0	.3

COMPUTED TRAP LOSSES

5 percent trap leakage rate

Trap Steam Losses	Trap Heat Losses
338.1 lbs/hr	403350.1 Btus/hr

SYSTEM MASS FLOWS

(1)	Steam to loads:	2486. lbm/hr
(2)	Steam condensed in pipes:	2272. lbm/hr
(3)	Steam condensed in vaults:	0. lbm/hr
(4)	Steam lost to trap leakage:	338. lbm/hr
(5)	Total steam plant output:	5096. lbm/hr
(6)	Pipe and vault condensate returned:	0. lbm/hr
(7)	Load condensate returned:	0. lbm/hr
(8)	Total condensate returned:	0. lbm/hr

SYSTEM HEAT LOSSES AND DISTRIBUTION EFFICIENCY
(M = Million)

(1)	Total pipe conduction heat losses:	1.945 MBtus/hr	56.99 %
(2)	Total pipe condensate heat losses:	.773 MBtus/hr	22.66 %
(3)	Total load condensate heat losses:	.291 MBtus/hr	8.53 %
(4)	Total vault conduction heat losses:	.000 MBtus/hr	.00 %
(5)	Total vault condensate heat losses:	.000 MBtus/hr	.00 %
(6)	Total trap heat losses:	.403 MBtus/hr	11.82 %
(7)	Total heat losses:	3.412 MBtus/hr	100.00 %
(8)	Total heat to loads:	2.648 MBtus/hr	
(9)	Total heat input to supply:	6.094 MBtus/hr	
(10)	Total heat returned to plant:	.000 MBtus/hr	
(11)	Net heat input from plant:	6.094 MBtus/hr	

DISTRIBUTION EFFICIENCY: 44.0% [1.0-(7)/(11)]

Line 4 Input File

SYSTEM VARIABLES AND EXECUTION CONTROLS

FLOW TOLERANCE = 1.00 lbm/hr
UNKNOWN PARAMETER TOLERANCE = .000500
UNKNOWN PRESSURE TOLERANCE = .000050
UNKNOWN NODE FLOW TOLERANCE = .500 lbm/hr
PC = 20 1 5 20 1 4 4 0 0 0
UNS = 1 2 2 2 4 3 1 1 2 2

PIPE DESCRIPTION SECTION

NCE NUM	FROM NODE	TO NODE	STATUS	DIAMETER (in)	LENGTH (ft)		RELATIVE ROUGHNESS	HEAT LOSS COEF (Btu/hr-ft-F)	TEMP (F)
1	4	A		8.1	2000.+	0.	.312E-3	1.16	65.0
2	A	684A		2.1	833.+	0.	.121E-2	.57	65.0
3	A	B		8.1	660.+	0.	.312E-3	1.16	65.0
4	B	C		8.1	288.+	0.	.312E-3	1.16	65.0
5	C	D		8.1	50.+	0.	.312E-3	1.16	65.0
6	C	C1		2.1	50.+	0.	.121E-2	.57	65.0
7	C1	371A		2.1	50.+	0.	.121E-2	.57	65.0
8	C1	C2		2.1	50.+	0.	.121E-2	.57	65.0
9	C2	372A		2.1	50.+	0.	.121E-2	.57	65.0
10	C2	373A		2.1	50.+	0.	.121E-2	.57	65.0
11	D	E		8.1	453.+	0.	.312E-3	1.16	65.0
12	D	D1		2.1	367.+	0.	.121E-2	.57	65.0
13	D1	422A		2.1	75.+	0.	.121E-2	.57	65.0
14	D1	D2		2.1	258.+	0.	.121E-2	.57	65.0
15	D2	421A		2.1	50.+	0.	.121E-2	.57	65.0
16	D2	454A		2.1	173.+	0.	.121E-2	.57	65.0
17	E	F		8.1	1625.+	0.	.312E-3	1.16	65.0
18	F	H		8.1	2000.+	0.	.312E-3	1.16	65.0
19	H	I		8.1	520.+	0.	.312E-3	1.16	65.0
20	H	210A		2.1	115.+	0.	.121E-2	.57	65.0
21	I	J		8.1	720.+	0.	.312E-3	1.16	65.0
22	J	K		8.1	525.+	0.	.312E-3	1.16	65.0
23	K	L		4.0	75.+	0.	.620E-3	.78	65.0
24	L	M		4.0	1313.+	0.	.620E-3	.78	65.0
25	M	N		4.0	403.+	0.	.620E-3	.78	65.0
26	N	110A		2.1	460.+	0.	.121E-2	.57	65.0
27	N	118A		3.1	161.+	0.	.814E-3	.68	65.0
28	I	O		8.1	230.+	0.	.312E-3	1.16	65.0
29	O	P		8.1	207.+	0.	.312E-3	1.16	65.0
30	O	144A		2.1	60.+	0.	.121E-2	.57	65.0
31	O	528A		2.1	207.+	0.	.121E-2	.57	65.0
32	P	Q		8.1	207.+	0.	.312E-3	1.16	65.0
33	P	143A		6.1	230.+	0.	.412E-3	.98	65.0
34	Q	R		4.0	230.+	0.	.620E-3	.78	65.0
35	Q	529A		2.1	50.+	0.	.121E-2	.57	65.0
36	Q	S		3.1	430.+	0.	.814E-3	.68	65.0
37	R	537A		2.1	728.+	0.	.121E-2	.57	65.0
38	R	314A		4.0	50.+	0.	.620E-3	.78	65.0
39	S	213A		3.1	138.+	0.	.814E-3	.68	65.0
40	S	129A		2.1	50.+	0.	.121E-2	.57	65.0
41	S	511A		2.6	207.+	0.	.105E-2	.62	65.0

REGULATOR AND VALVE DESCRIPTION SECTION

NCE NUM	FROM NODE	TO NODE	STATUS	SIZING COEFFICIENT	CONFIGURATION CONSTANT	MINIMUM PRESSURE DROP
42	210A	2101	UNKNOWN	3.00	35.00	.0
43	213A	2131	UNKNOWN	3.00	35.00	.0
44	314A	3148	UNKNOWN	3.00	35.00	.0
45	537A	537	UNKNOWN	3.00	35.00	.0
46	511A	5111	UNKNOWN	3.00	35.00	.0
47	528A	5128	UNKNOWN	3.00	35.00	.0
48	529A	5129	UNKNOWN	3.00	35.00	.0
49	129A	1294	UNKNOWN	3.00	35.00	.0
50	143A	5143	UNKNOWN	3.00	35.00	.0
51	144A	5144	UNKNOWN	3.00	35.00	.0
52	684A	684	UNKNOWN	3.00	35.00	.0
53	110A	1101	UNKNOWN	3.00	35.00	.0
54	118A	5118	UNKNOWN	3.00	35.00	.0
55	421A	421	UNKNOWN	3.00	35.00	.0
56	422A	422	UNKNOWN	3.00	35.00	.0
57	371A	1371	UNKNOWN	3.00	35.00	.0
58	372A	1372	UNKNOWN	3.00	35.00	.0
59	373A	1373	UNKNOWN	3.00	35.00	.0
60	454A	454	UNKNOWN	3.00	35.00	.0

TRAP INPUT DATA

5.0 percent trap leakage

VAULT INPUT DATA

VAULT NUMBER	NODE NAME	MAIN PIPE DIAMETER (in)	MAIN PIPE LENGTH (ft)	HEAT TRANSFER COEFFICIENT (Btu/hr-ft-F)	ENVIROMENT TEMPERATURE (F)

NODE INPUT DATA

NODE NAME	PRESSURE (psig)	NODE FLOW (lbm/hr)	NODE FLOW RETURNED	PIPE CONDS RETURNED	LOAD CONDS TEMPERATURE
4	155.00	80000.?	.00	.00	150.0
A	150.00?	0.	.00	.00	150.0
B	150.00?	0.	.00	.00	150.0
C	150.00?	0.	.00	.00	150.0
C1	150.00?	0.	.00	.00	150.0
C2	150.00?	0.	.00	.00	150.0
D	150.00?	0.	.00	.00	150.0
D1	150.00?	0.	.00	.00	150.0
D2	150.00?	0.	.00	.00	150.0
E	150.00?	0.	.00	.00	150.0
F	150.00?	0.	.00	.00	150.0
H	150.00?	0.	.00	.00	150.0
I	150.00?	0.	.00	.00	150.0
J	150.00?	0.	.00	.00	150.0
K	150.00?	0.	.00	.00	150.0
L	150.00?	0.	.00	.00	150.0
M	150.00?	0.	.00	.00	150.0
N	150.00?	0.	.00	.00	150.0
O	150.00?	0.	.00	.00	150.0
P	150.00?	0.	.00	.00	150.0
Q	150.00?	0.	.00	.00	150.0
R	150.00?	0.	.00	.00	150.0
S	150.00?	0.	.00	.00	150.0
2101	60.00	-54.	.00	.00	150.0
2131	60.00	-36.	.00	.00	150.0
3148	60.00	-1118.	.00	.00	150.0
537	60.00	-175.	.00	.00	150.0
5111	60.00	-96.	.00	.00	150.0
5128	60.00	-14.	.00	.00	150.0
5129	60.00	-355.	.00	.00	150.0
1294	60.00	-123.	.00	.00	150.0
5143	60.00	-256.	.00	.00	150.0
5144	60.00	-53.	.00	.00	150.0
684	60.00	-47.	.00	.00	150.0
1101	15.00	-259.	.00	.00	150.0
5118	15.00	-92.	.00	.00	150.0
421	60.00	-3.	.00	.00	150.0
422	60.00	-312.	.00	.00	150.0
1371	60.00	-26.	.00	.00	150.0
1372	60.00	-26.	.00	.00	150.0
1373	60.00	-26.	.00	.00	150.0
454	60.00	-10.	.00	.00	150.0
210A	60.00?	0.	.00	.00	.0
213A	60.00?	0.	.00	.00	.0
314A	60.00?	0.	.00	.00	.0
537A	60.00?	0.	.00	.00	.0
511A	60.00?	0.	.00	.00	.0
528A	60.00?	0.	.00	.00	.0
529A	60.00?	0.	.00	.00	.0
129A	60.00?	0.	.00	.00	.0
143A	60.00?	0.	.00	.00	.0
144A	60.00?	0.	.00	.00	.0
684A	60.00?	0.	.00	.00	.0
110A	75.00?	0.	.00	.00	.0
118A	60.00?	0.	.00	.00	.0
421A	60.00?	0.	.00	.00	.0
422A	60.00?	0.	.00	.00	.0
371A	60.00?	0.	.00	.00	.0
372A	60.00?	0.	.00	.00	.0
373A	60.00?	0.	.00	.00	.0
454A	60.00?	0.	.00	.00	.0

NODE CORRESPONDENCE TABLE AND LIST OF ADJACENT NODES

NODE NUMBER	NODE NAME	ADJACENT NODES (BY NAME)			
1	4	A			
2	A	684A	B	4	
3	B	C	A		
4	C	D	C1	B	
5	C1	371A	C2	C	
6	C2	372A	373A	C1	
7	D	E	D1	C	
8	D1	422A	D2	D	
9	D2	421A	454A	D1	
10	E	F	D		
11	F	H	E		
12	H	I	210A	F	
13	I	J	O	H	
14	J	K	I		
15	K	L	J		
16	L	M	K		
17	M	N	L		
18	N	110A	118A	M	
19	O	P	144A	528A	I
20	P	Q	143A	O	
21	Q	R	529A	S	P
22	R	537A	314A	Q	
23	S	213A	129A	511A	Q
24	2101	210A			
25	2131	213A			
26	3148	314A			
27	537	537A			
28	5111	511A			
29	5128	528A			
30	5129	529A			
31	1294	129A			
32	5143	143A			
33	5144	144A			
34	684	684A			
35	1101	110A			
36	5118	118A			
37	421	421A			
38	422	422A			
39	1371	371A			
40	1372	372A			
41	1373	373A			
42	454	454A			
43	210A	2101	H		
44	213A	2131	S		
45	314A	3148	R		
46	537A	537	R		
47	511A	5111	S		
48	528A	5128	O		
49	529A	5129	Q		
50	129A	1294	S		
51	143A	5143	P		
52	144A	5144	O		

NODE CORRESPONDENCE TABLE AND LIST OF ADJACENT NODES

NODE NUMBER	NODE NAME	ADJACENT NODES(BY NAME)
53	684A	684 A
54	110A	1101 N
55	118A	5118 N
56	421A	421 D2
57	422A	422 D1
58	371A	1371 C1
59	372A	1372 C2
60	373A	1373 C2
61	454A	454 D2

***** PROBLEM SUMMARY *****
61 NODES IN THE SYSTEM
41 PIPES IN THE SYSTEM
19 VALVES OR REGULATORS
5 PERCENT TRAP LEAKAGE
0 VAULTS IN THE SYSTEM
19 UNKNOWN PARAMETERS
41 UNKNOWN PRESSURES

03/03/94 14:50:24
iaap465

Iowa Army Ammunition Plant
Line 4 - 65 degrees F High Pressure

SOLUTION COMPLETED IN 11 ITERATIONS
SOME NODES MAY NOT BE BALANCED

*** PROBLEM SUMMARY ***
61 NODES IN THE SYSTEM
41 PIPES IN THE SYSTEM
19 VALVES OR REGULATORS
5 PERCENT TRAP LEAKAGE
0 VAULTS IN THE SYSTEM
19 UNKNOWN PARAMETERS
41 UNKNOWN PRESSURES
1 UNKNOWN FLOWS

COMPUTED NODE DATA

NODE NAME	PRESSURE (psig)	NODE FLOW (lbm/hr)	CONDS FLOW (lbm/hr)	FLOW LOSS (Btu/hr)	CONDS LOSS (Btu/hr)	TEMP (F)	RESIDUAL (lbm/hr)
4	155.00	8998.5?	-411.0	.0	140160.2	368.3	.05
A	154.34?	.0	-630.6	.0	214860.6	368.0	-.73
B	154.16?	.0	-194.7	.0	66309.9	367.9	.11
C	154.08?	.0	-74.4	.0	25354.9	367.8	-1.35
C1	154.07?	.0	-15.1	.0	5156.3	367.8	-3.54
C2	154.07?	.0	-15.1	.0	5156.2	367.8	.85
D	154.07?	.0	-140.3	.0	47773.4	367.8	1.33
D1	153.50?	.0	-70.6	.0	24012.9	367.6	.03
D2	153.47?	.0	-48.5	.0	16499.1	367.5	-5.21
E	153.98?	.0	-426.5	.0	145239.7	367.8	-.11
F	153.69?	.0	-743.8	.0	253163.2	367.7	-.07
H	153.41?	.0	-528.5	.0	179813.1	367.5	1.89
I	153.35?	.0	-301.5	.0	102566.1	367.5	1.40
J	153.34?	.0	-255.3	.0	86868.6	367.5	-1.74
K	153.34?	.0	-118.0	.0	40149.3	367.5	1.07
L	153.32?	.0	-191.4	.0	65101.2	367.5	-.21
M	153.16?	.0	-236.6	.0	80462.1	367.4	.07
N	153.13?	.0	-121.2	.0	41226.5	367.4	8.82
O	153.34?	.0	-116.5	.0	39643.9	367.5	-6.64
P	153.33?	.0	-124.8	.0	42441.7	367.5	-20.23
Q	153.32?	.0	-130.9	.0	44527.0	367.5	.20
R	153.23?	.0	-111.9	.0	38068.4	367.4	-10.21
S	153.26?	.0	-96.0	.0	32656.6	367.4	-13.58
2101	60.00	-53.9	.0	6308.9	.0	307.3	.00
2131	60.00	-36.4	.0	4260.6	.0	307.3	.00
3148	60.00	-1118.0	.0	130860.3	.0	307.3	.00
537	60.00	-174.6	.0	20436.7	.0	307.3	.00
5111	60.00	-96.4	.0	11283.5	.0	307.3	.00
5128	60.00	-13.9	.0	1627.0	.0	307.3	.00
5129	60.00	-355.1	.0	41563.9	.0	307.3	.00
1294	60.00	-122.8	.0	14373.6	.0	307.3	.00
5143	60.00	-256.0	.0	29964.4	.0	307.3	.00
5144	60.00	-52.7	.0	6168.5	.0	307.3	.00
684	60.00	-47.1	.0	5513.0	.0	307.3	.00
1101	15.00	-258.9	.0	30303.9	.0	249.7	.00
5118	15.00	-92.1	.0	10780.2	.0	249.7	.00
421	60.00	-3.2	.0	374.6	.0	307.3	.00
422	60.00	-311.6	.0	36472.3	.0	307.3	.00
1371	60.00	-25.9	.0	3031.6	.0	307.3	.00
1372	60.00	-25.9	.0	3031.6	.0	307.3	.00
1373	60.00	-25.9	.0	3031.6	.0	307.3	.00
454	60.00	-10.4	.0	1217.3	.0	307.3	.00
210A	153.40?	.0	-11.6	.0	3943.7	367.5	-1.72
213A	153.26?	.0	-16.6	.0	5642.7	367.4	12.22
314A	153.22?	.0	-6.9	.0	2344.6	367.4	10.32
537A	152.93?	.0	-73.3	.0	24927.5	367.3	-.04
511A	153.25?	.0	-22.7	.0	7717.1	367.4	1.32
528A	153.34?	.0	-20.9	.0	7096.9	367.5	3.61
529A	153.28?	.0	-5.0	.0	1713.7	367.5	.09
129A	153.25?	.0	-5.0	.0	1713.7	367.4	.04
143A	153.33?	.0	-39.9	.0	13557.2	367.5	18.38
144A	153.34?	.0	-6.0	.0	2057.1	367.5	3.86

COMPUTED NODE DATA

NODE NAME	PRESSURE (psig)	NODE FLOW (lbm/hr)	CONDS FLOW (lbm/hr)	FLOW LOSS (Btu/hr)	CONDS LOSS (Btu/hr)	TEMP (F)	RESIDUAL (lbm/hr)
684A	154.23?	.0	-84.1	.0	28652.5	367.9	.64
110A	152.86?	.0	-46.3	.0	15746.1	367.3	.00
118A	153.13?	.0	-19.3	.0	6580.3	367.4	-8.83
421A	153.47?	.0	-5.0	.0	1715.1	367.5	.78
422A	153.45?	.0	-7.6	.0	2572.2	367.5	-.01
371A	154.07?	.0	-5.0	.0	1718.8	367.8	3.69
372A	154.07?	.0	-5.0	.0	1718.7	367.8	-.47
373A	154.07?	.0	-5.0	.0	1718.7	367.8	-.47
454A	153.47?	.0	-17.4	.0	5934.1	367.5	4.41

COMPUTED PIPE FLOWS AND PARAMETERS

FROM NODE	TO NODE	STATUS	FLOW (lbm/hr)	CONDENSATE (lbm/hr)	HEAT LOSS (Btu/hr)	DIAMETER (in)	RE NUMBER	FRIC FACTOR
4	A		8579.1	821.93	703250.3	8.07	3.29E+5	1.71E-2
A	684A		143.8	168.22	143838.9	2.07	2.15E+4	2.83E-2
A	B		7797.2	271.08	231918.8	8.07	2.99E+5	1.72E-2
B	C		7594.1	118.27	101180.4	8.07	2.92E+5	1.72E-2
C	D		7337.2	20.53	17564.8	8.07	2.82E+5	1.73E-2
C	C1		175.6	10.09	8631.0	2.07	2.63E+4	2.73E-2
C1	371A		46.6	10.09	8630.9	2.07	6.97E+3	3.66E-2
C1	C2		109.1	10.09	8630.9	2.07	1.63E+4	2.97E-2
C2	372A		42.4	10.09	8630.9	2.07	6.35E+3	3.56E-2
C2	373A		42.4	10.09	8630.9	2.07	6.35E+3	3.56E-2
D	E		6660.8	186.01	159124.2	8.07	2.56E+5	1.74E-2
D	D1		526.6	74.00	63322.0	2.07	7.88E+4	2.38E-2
D1	422A		331.1	15.12	12934.1	2.07	4.95E+4	2.50E-2
D1	D2		116.7	52.02	44494.0	2.07	1.75E+4	2.93E-2
D2	421A		21.0	10.08	8622.7	2.07	3.14E+3	3.16E-2
D2	454A		44.2	34.88	29834.5	2.07	6.61E+3	3.05E-2
E	F		6226.1	667.00	570636.8	8.07	2.39E+5	1.75E-2
F	H		5474.2	820.51	702004.1	8.07	2.10E+5	1.77E-2
H	I		4859.9	213.28	182472.0	8.07	1.87E+5	1.79E-2
H	210A		75.7	23.18	19830.1	2.07	1.13E+4	3.22E-2
I	J		1398.7	295.33	252640.2	8.07	5.37E+4	2.16E-2
J	K		1136.9	215.35	184215.1	8.07	4.36E+4	2.24E-2
K	L		1009.6	20.68	17695.3	4.03	7.76E+4	2.16E-2
L	M		810.2	362.04	309741.6	4.03	6.23E+4	2.23E-2
M	N		565.4	111.11	95054.9	4.03	4.35E+4	2.36E-2
N	110A		314.8	92.63	79269.1	2.07	4.71E+4	2.51E-2
N	118A		112.3	38.70	33105.5	3.07	1.13E+4	3.83E-2
I	O		3150.1	94.34	80704.3	8.07	1.21E+5	1.89E-2
O	P		2907.1	84.90	72632.7	8.07	1.12E+5	1.91E-2
O	144A		74.5	12.09	10345.0	2.07	1.12E+4	3.26E-2
O	528A		50.3	41.72	35690.3	2.07	7.53E+3	3.30E-2
P	Q		2468.2	84.90	72631.8	8.07	9.47E+4	1.96E-2
P	143A		326.2	79.70	68179.6	6.07	1.66E+4	2.84E-2
Q	R		1516.8	63.41	54260.8	4.03	1.17E+5	2.07E-2
Q	529A		372.2	10.08	8620.4	2.07	5.57E+4	2.46E-2
Q	S		439.9	103.38	88440.4	3.07	4.44E+4	2.41E-2
R	537A		259.8	146.63	125468.3	2.07	3.89E+4	2.57E-2
R	314A		1147.1	13.79	11794.8	4.03	8.82E+4	2.16E-2
S	213A		77.1	33.18	28381.7	3.07	7.78E+3	3.18E-2
S	129A		139.8	10.08	8619.7	2.07	2.09E+4	2.82E-2
S	511A		132.3	45.37	38815.9	2.57	1.60E+4	2.96E-2

COMPUTED VALVE AND REGULATOR FLOWS AND PARAMETERS

FROM NODE	TO NODE	STATUS	FLOW (lbm/hr)	Cs
210A	2101	?	57.6	.4
213A	2131	?	40.1	.3
314A	3148	?	1121.7	7.0
537A	537	?	178.3	1.1
511A	5111	?	100.1	.6
528A	5128	?	17.6	.1
529A	5129	?	358.8	2.2
129A	1294	?	126.5	.8
143A	5143	?	259.7	1.6
144A	5144	?	56.4	.4
684A	684	?	50.8	.3
110A	1101	?	260.3	1.6
118A	5118	?	93.5	.6
421A	421	?	6.9	.0
422A	422	?	315.3	2.0
371A	1371	?	29.6	.2
372A	1372	?	29.6	.2
373A	1373	?	29.6	.2
454A	454	?	14.1	.1

COMPUTED TRAP LOSSES

5 percent trap leakage rate

Trap Steam Losses	Trap Heat Losses
411.7 lbs/hr	491253.6 Btus/hr

SYSTEM MASS FLOWS

(1)	Steam to loads:	3081.	lbm/hr
(2)	Steam condensed in pipes:	5506.	lbm/hr
(3)	Steam condensed in vaults:	0.	lbm/hr
(4)	Steam lost to trap leakage:	412.	lbm/hr
(5)	Total steam plant output:	8998.	lbm/hr
(6)	Pipe and vault condensate returned:	0.	lbm/hr
(7)	Load condensate returned:	0.	lbm/hr
(8)	Total condensate returned:	0.	lbm/hr

SYSTEM HEAT LOSSES AND DISTRIBUTION EFFICIENCY
(M = Million)

(1)	Total pipe conduction heat losses:	4.710	MBtus/hr	63.34 %
(2)	Total pipe condensate heat losses:	1.874	MBtus/hr	25.20 %
(3)	Total load condensate heat losses:	.361	MBtus/hr	4.85 %
(4)	Total vault conduction heat losses:	.000	MBtus/hr	.00 %
(5)	Total vault condensate heat losses:	.000	MBtus/hr	.00 %
(6)	Total trap heat losses:	.491	MBtus/hr	6.61 %
(7)	Total heat losses:	7.437	MBtus/hr	100.00 %
(8)	Total heat to loads:	3.274	MBtus/hr	
(9)	Total heat input to supply:	10.760	MBtus/hr	
(10)	Total heat returned to plant:	.000	MBtus/hr	
(11)	Net heat input from plant:	10.760	MBtus/hr	

DISTRIBUTION EFFICIENCY: 30.9% [1.0-(7)/(11)]

Regression Equations for Current Steam Use and Expected Savi

Line 4		High Pr	SDCS	Savings	Regression
-15	225	26360	25574	786	783.17
5	25	22052	21124	928	934.11
25	625	17719	16662	1057	1055.63
45	2025	13367	12215	1152	1147.71
65	4225	8998	7790	1208	1210.37

Line 2		High Pr	SDCS	Savings	Regression
-15	225	19273	18897	376	376.06
5	25	15769	15321	448	447.77
25	625	12257	11752	505	505.34
45	2025	8739	8190	549	548.77
65	4225	5215	4637	578	578.06

Line 3		Pr	SDCS	Savings	Regression
-15	225	18353	18095	258	258.51
5	25	15069	14702	367	365.94
25	625	11762	11312	450	450.09
45	2025	8436	7926	510	510.94
65	4225	5096	4547	549	548.51

Regression Equations for Current Steam Use and Expected Savings

All regressions are in lbs/hr

Line 4		High Pr	SDCS	Savings	Regression
-15	225	26360	25574	786	783.17
5	25	22052	21124	928	934.11
25	625	17719	16662	1057	1055.63
45	2025	13367	12215	1152	1147.71
65	4225	8998	7790	1208	1210.37

Savings Regression Output:			Current Use Regression Output:		
Constant		899.1375	Constant		23129.73
Std Err of Y Est		5.968967	Std Err of Y Est		1.820518
R Squared		0.999392	R Squared		1
No. of Observations		5	No. of Observations		5
Degrees of Freedom		2	Degrees of Freedom		2
X Coefficient(s)	7.179286	-0.03679	X Coefficient(s)	-215.786	-0.02518
Std Err of Coef.	0.220615	0.003988	Std Err of Coef.	0.067287	0.001216

Line 2		High Pr	SDCS	Savings	Regression
-15	225	19273	18897	376	376.06
5	25	15769	15321	448	447.77
25	625	12257	11752	505	505.34
45	2025	8739	8190	549	548.77
65	4225	5215	4637	578	578.06

Regression Output:			Regression Output:		
Constant		431.1688	Constant		16645.29
Std Err of Y Est		0.338062	Std Err of Y Est		0.478091
R Squared		0.999991	R Squared		1
No. of Observations		5	No. of Observations		5
Degrees of Freedom		2	Degrees of Freedom		2
X Coefficient(s)	3.408929	-0.01768	X Coefficient(s)	-175.319	-0.00821
Std Err of Coef.	0.012495	0.000226	Std Err of Coef.	0.01767	0.000319

Line 3		High Pr	SDCS	Savings	Regression
-15	225	18353	18095	258	258.51
5	25	15069	14702	367	365.94
25	625	11762	11312	450	450.09
45	2025	8436	7926	510	510.94
65	4225	5096	4547	549	548.51
93.6		3.7216	348.3418		

Regression Output:			Regression Output:		
Constant		341.2688	Constant		15890.67
Std Err of Y Est		1.121224	Std Err of Y Est		2.014235
R Squared		0.999954	R Squared		1
No. of Observations		5	No. of Observations		5
Degrees of Freedom		2	Degrees of Freedom		2
X Coefficient(s)	5.080357	-0.02911	X Coefficient(s)	-164.565	-0.02339
Std Err of Coef.	0.041441	0.000749	Std Err of Coef.	0.074447	0.001346

Appendix D - Steam Trap and Pressure Reducing Valve Specification Sheets

SERIES TWENTY TEN STAINLESS STEEL TRAPS

for pressues to 400 psig...and capacities to 860 lbs/hr

The 2010 Series with 360° universal connector allows you to install inverted bucket efficiency and long service life in *any* piping configuration, with little or no repiping. Series 2010 traps combine savings in three important areas: energy, installation, and replacement.

The 2010 Series with 360° universal connector provides quick, easy in-line renewability along with all the advantages of all stainless steel construction and the proven inverted bucket operating principle.

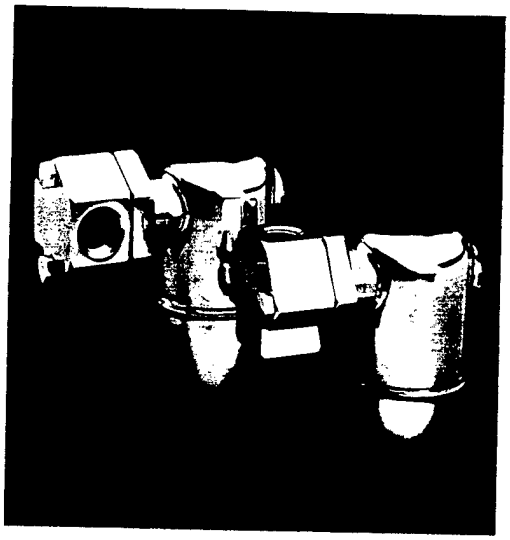
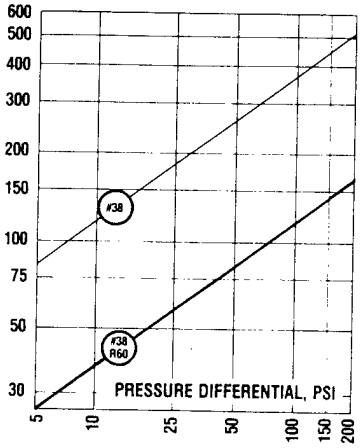
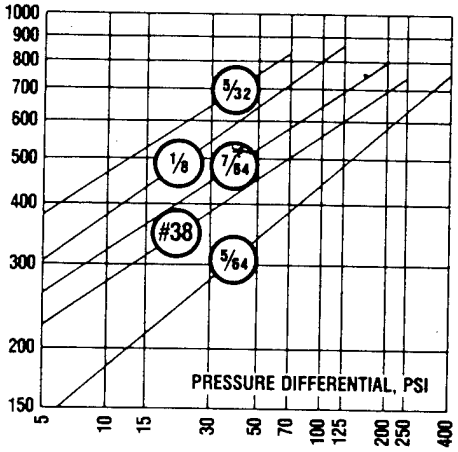


CHART 11-1. CAPACITIES, ARMSTRONG SERIES 2010 TRAPS

Model 2010 TRAP CAPACITY



Model 2011 TRAP CAPACITY



Continuous discharge capacities in pounds of hot condensate per hour at pressure differential indicated.

TABLE 11-1

Physical Data, Series 2010 Traps		
Model No.	2010	2011
Pipe Connections	½", ¾"	½", ¾"
A	2 11/16"	2 11/16"
B	2 3/4"	2 3/4"
C	2 3/8"	2 3/8"
D	4 19/32"	5 37/64"
E	1 11/32"	1 11/32"
F	4 9/16"	4 9/16"
G	1"	1"
H	1 3/8"	1 3/8"
I	1 3/8"	1 3/8"
Weight	4 1/4 lbs.	4 1/2 lbs.
Vessel Design Limitations (Maximum allowable pressure)	*400 psig @ 800° F	400 psig @ 800° F

*Maximum Operating Pressure 200 psig (14 bar)
All dimensions and weights are approximate. Use certified print for exact dimensions.

Fig. 11-1

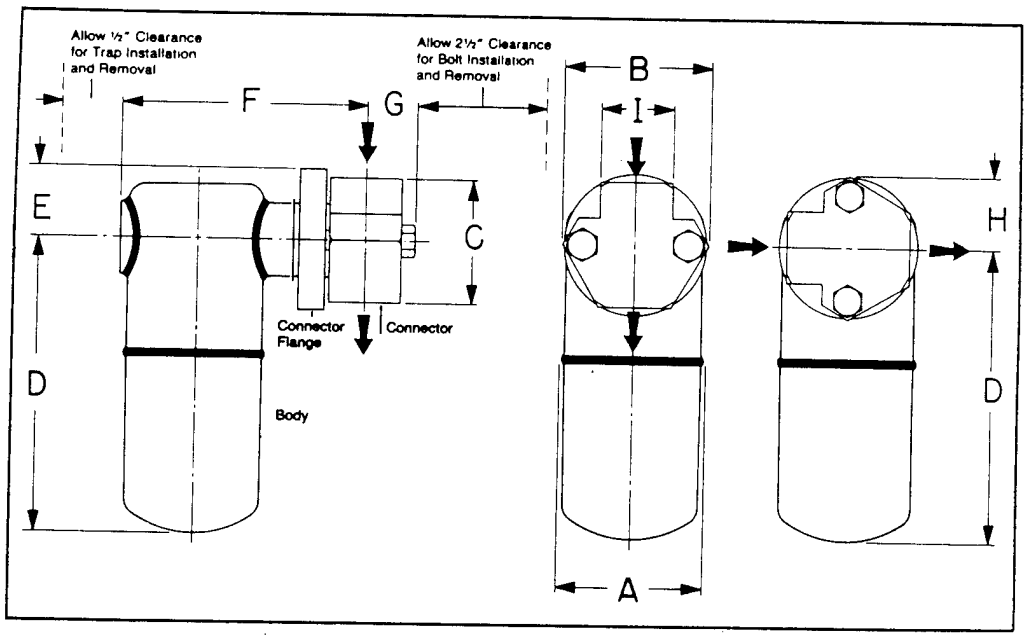


TABLE 11-2

Orifices, Series 2010 Traps Maximum Differential Pressure		
Trap No.	2010	2011
Pipe Connection	½", ¾"	½", ¾"
Orifice Size	PSI	PSI
5/32"	—	70
1/8"	—	125
7/64"	—	200
#38	200	250
5/64"	—	400
#38 R60*	200	—

*Because the orifice is located at the top, inverted bucket steam traps handle dirt and scale better than other types of traps. However, in applications where extremely dirty conditions exist, care should be exercised in the use of all types of restricted-orifice, reduced-capacity traps.

LAMAR - FISHER ?C ?
STEAM PRV's

Table 4. Port Diameters, and Capacities in Pounds of Saturated Steam Per Hour at 10% Droop*

PRESSURE, PSIG		PORT DIAMETER, INCHES 3/4"		1-1/4"		1-1/2"	2"	2-1/2"	3"	4"	6"
Inlet	Outlet Setting	1/2" Body	3/4" Body	1" Body	1-1/4" Body	1-1/2" Body	2" Body	2-1/2" Body	3" Body	4" Body	6" Body
250	150	1460	2050	4050	4910	6780	11500	17000	23000	31000	46600
	140	1490	2380	4160	5470	7860	12700	19300	26300	37000	58400
	100	1600	2530	4460	5650	8150	13400	19800	27500	38800	62900
	80	1600	2520	4460	5640	8130	13400	19700	27400	38700	62800
	60	1600	2520	4460	5630	8100	13300	19700	27300	38500	62600
	40	1600	2510	4460	5610	7920	13200	19300	27300	37800	62300
	20	1600	2510	4460	5580	7850	13000	19100	27200	37300	62000
200	150	1000	1810	2790	4370	6070	10200	15000	19700	28300	47400
	120	1160	1880	3280	4500	6300	10500	15500	20700	29700	49000
	100	1300	1950	3610	4550	6250	10700	15600	21700	30700	50300
	80	1300	2050	3610	4560	6550	11000	15700	22500	31300	51500
	60	1300	2040	3610	4550	6520	10900	15700	22000	31200	51400
	40	1300	2030	3610	4640	6500	10800	15500	21900	31000	51200
	20	1300	2030	3610	4540	6480	10700	15500	21900	29500	51000
150	120	700	1240	1950	3020	4090	7070	10000	13700	18600	30600
	100	857	1390	2360	3390	4600	7740	11500	15200	21700	36100
	80	995	1500	2770	3570	4980	8130	12100	15900	23500	38300
	60	995	1560	2770	3620	5110	8300	12300	16800	23800	40200
	40	995	1550	2770	3600	5070	8260	12200	16700	23700	40100
	20	995	1540	2770	3580	5000	8220	12200	16700	23600	39800
125	100	590	965	1630	2460	3250	5400	8100	11300	15600	25500
	80	750	1210	2100	2950	4100	6750	10000	13700	18500	31000
	60	835	1310	2340	3110	4400	7250	10800	14400	19800	33500
	40	835	1310	2340	3040	4280	7080	10500	14200	19800	33500
	20	835	1300	2340	3010	4230	7080	10500	14100	19800	33500
	10	835	1280	2340	2970	4170	7010	10400	14100	19800	33200
	5	810	1270	2310	2940	4140	6950	10400	13900	19600	33000
100	80	478	867	1330	2020	2860	4960	7230	9670	13000	21700
	60	615	968	1700	2380	3330	5650	8370	11000	15200	25500
	40	690	1080	1920	2480	3500	5930	8660	11800	16500	27400
	20	690	1070	1920	2470	3460	5900	8630	11800	16400	27300
	10	690	1060	1920	2450	3440	5870	8610	11700	16400	27200
	5	655	1040	1900	2420	3400	5710	8550	11500	16100	27000
75	60	366	625	1020	1540	2120	4160	5370	6900	8280	15700
	50	448	711	1240	1670	2380	4370	5600	7680	9240	18000
	40	496	798	1380	1810	2640	4590	5840	8470	10200	20300
	30	531	827	1470	1850	2680	4680	6270	8880	10800	20800
	20	540	857	1500	1900	2720	4770	6700	9290	11300	21300
	10	540	845	1500	1840	2620	4700	6540	9160	11200	21200
	5	540	836	1500	1790	2510	4610	6420	9080	10900	21000
50	40	261	420	710	1030	1660	2590	3750	4980	6650	11600
	30	324	499	928	1170	1760	2940	4210	5740	7730	13200
	20	388	578	1080	1320	1860	3290	4680	6500	8810	14700
	10	388	608	1080	1370	1890	3390	4780	6650	9110	15600
	5	388	590	1080	1330	1830	3300	4650	6500	8960	15400
25	15	190	293	525	675	935	1860	2520	3260	4520	7570
	10	217	338	600	755	1080	2080	3020	3850	5000	8800
	5	238	333	660	749	1060	2080	2980	3900	4940	8730

*Printed capacities are for the Type 92B. To determine Type 92P capacities, multiply the printed values by 0.75 for outlet settings of 10 psig or greater and by 0.5 for 5 psig outlet settings.

Mike's

Division Mgr
3 wks

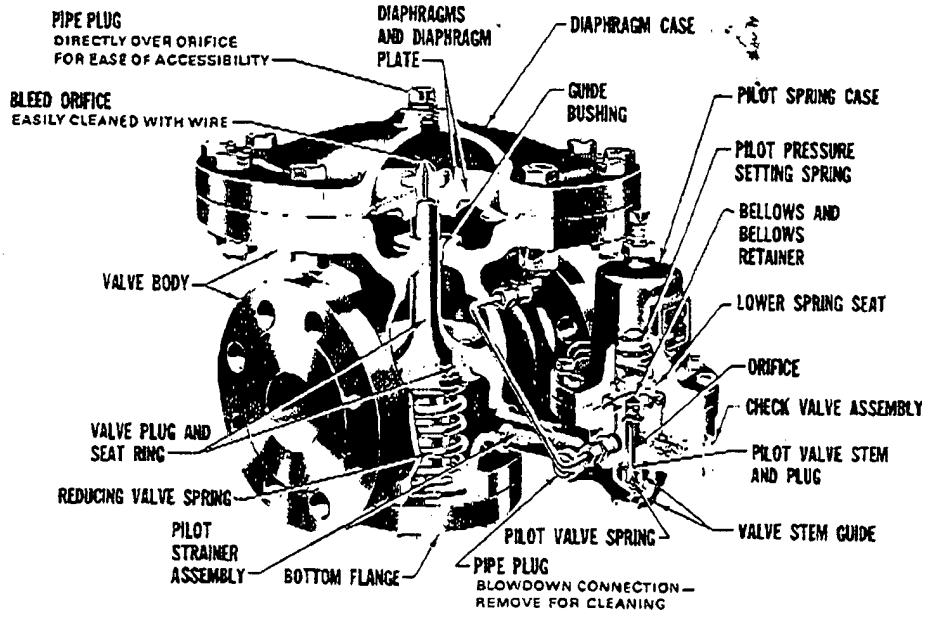


Figure 2. Typical Type 92B Construction

Table 3. Pressure Specifications, Psi

DESCRIPTION			NOMINAL BODY SIZE, INCHES				
			Screwed and Class 250 Flanged Ends			Class 125 Flanged Ends	
			1/2, 3/4	1, 1-1/4, 1-1/2, 2	2-1/2, 3, 4, 6	1/2, 3/4, 1, 1-1/4, 1-1/2, 2	2-1/2, 3, 4, 6
Body Rating and Maximum Inlet			250	250	250	125	125
Outlet, Type 92P (For Type 92B See Table 2)		Minimum	2	2	2	2	2
		Maximum	245	150	150	120	120
Maximum Valve Differential			150	150	150	123	123
Minimum Differential Pressures Required for Full Stroke	Type 92B	SST Spring (Standard)	20	20	20	20	20
		Inconel Spring (Optional)	10	10	10	10	10
	Type 92P		5	5	5	5	5
Maximum Allowable Diaphragm Differential, Type 92P (For Type 92B See Principle of Operation Section)			150	150	100	120	100

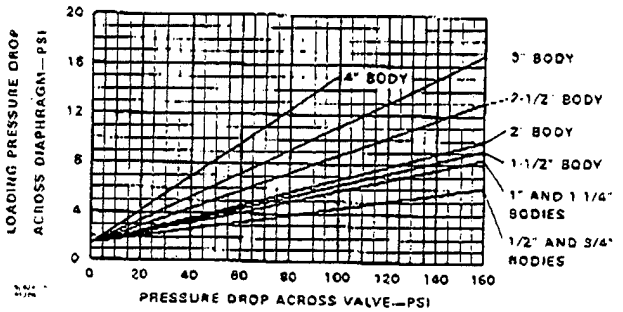


Figure 3. Type 92P Differential Pressure Ratios

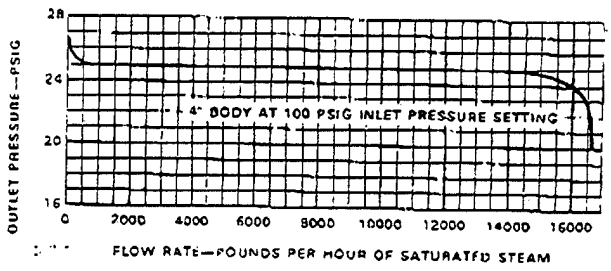


Figure 4. Type 92B Steam Capacity and Regulation Curve

Appendix E - Minimum PRV Sizes for Buildings

COMPUTED VALVE AND REGULATOR FLOWS AND PARAMETERS
For Line 2

FROM NODE	TO NODE	STATUS	FLOW (lbm/hr)	Cs	Required PRV Size (inches)
201A	201	?	2432.5	15.4	2.00
203A	203	?	27.6	.2	0.50
204A	204	?	5686.4	35.8	3.00
51A	51	?	1798.4	11.7	1.50
52A	52	?	1798.4	11.5	1.50
212A	212	?	1523.6	10.8	1.25
215A	215	?	22.4	.2	0.50
213A	213	?	1809.7	13.6	1.50
251A	251	?	20.7	.1	0.50
252A	252	?	259.4	1.6	0.50
701A	701	?	38.9	.3	0.50
702A	702	?	38.9	.2	0.50
137A	137	?	452.3	3.1	0.75

COMPUTED VALVE AND REGULATOR FLOWS AND PARAMETERS
For Line 3

FROM NODE	TO NODE	STATUS	FLOW (lbm/hr)	Cs	Required PRV Size (inches)
301A	301	?	1769.1	11.4	1.50
303A	303	?	27.6	.2	0.50
304A	304	?	5453.2	36.8	3.00
51A	51	?	1514.7	11.7	1.25
52A	52	?	1551.3	11.5	1.50
62A	62	?	92.7	.8	0.50
81A	81	?	92.7	.2	0.50
310A	310	?	2312.8	20.6	2.00
312A	312	?	1523.2	13.1	1.25
161A	161	?	27.6	.6	0.50
317A	317	?	27.6	.3	0.50
350A	350	?	332.5	2.2	0.50
351A	351	?	20.8	.1	0.50
352A	352	?	259.4	1.7	0.50
701A	701	?	38.9	.3	0.50
702A	702	?	38.9	.3	0.50
383A	383	?	37.3	.2	0.50
137A	137	?	272.7	2.2	0.50

COMPUTED VALVE AND REGULATOR FLOWS AND PARAMETERS
For Line 4

FROM NODE	TO NODE	STATUS	FLOW (lbm/hr)	Cs	Required PRV Size (inches)
210A	2101	?	372.8	2.4	0.75
213A	2131	?	253.7	1.2	0.50
314A	3148	?	7665.7	55.8	4.00
537A	537	?	178.3	1.7	0.50
511A	5111	?	664.9	4.5	1.00
528A	5128	?	17.6	.8	0.50
529A	5129	?	2438.0	17.2	2.00
129A	1294	?	126.5	.6	0.50
143A	5143	?	1758.1	12.1	1.50
144A	5144	?	365.2	2.6	0.50
684A	684	?	326.8	2.3	0.50
110A	1101	?	1775.5	12.2	1.50
118A	5118	?	632.7	4.1	0.75
421A	421	?	6.9	.0	0.50
422A	422	?	2139.3	15.6	2.00
371A	1371	?	180.8	1.2	0.50
372A	1372	?	180.8	1.2	0.50
373A	1373	?	180.8	1.2	0.50
454A	454	?	14.1	.1	0.50

Appendix F -Fisher Control Valve Specification Sheets

QUOTE NO. 19306
DATE: 4-15-94

FAX QUOTATION

TOTAL NO. OF PAGES: 4

TO: Army Corps of Engineers - Chris Dilks
FAX: 217-373-3430
FROM: Rob Ciganek / Carl Lathrop

GENERAL METERS & CONTROLS
ELK GROVE VILLAGE, IL
708-956-8020 PHONE
708-956-9870 FAX

REFERENCE: Fisher control valve

TO HELP US SERVE YOU BETTER, PLEASE USE THE ABOVE QUOTE NO. WHEN ORDERING.

ITEM	QTY	DESCRIPTION
1	3	4" Fisher model ED control valve with electric operator per the attached specification sheet. Unit net price..... $ 6500.00 The above control valve contains whisper trim to maintain a noise level < 90 dba. See the attached sizing report. The same valve can be used in both the 6" and the 8" lines. If you have any questions please call.

Thank You

DELIVERY: **8 Weeks**
F.O.B.:**Factory**
TERMS: PER THE ATTACHED

PLEASE ADDRESS YOUR ORDER TO:
GENERAL METERS & CONTROLS
AT: PO BOX 625, ELK GROVE VILLAGE, IL 60009-0625

(General Meters & Controls) SLIDING STEM CONTROL VALVE SPECIFICATION

ARMY CORPS 4-15-94
Reference:
Quote:
Order:
Item: 1 Rev: Qty: 1 Engineer:

Service:

Tag:
Size and Type: 4" ED

Body Style: GLOBE
Design Temp: F
Design Pres: psig
End Connect: ANSI CLASS 150
In: RF FLG
Out: RF FLG
Material: WCB CARBON STL CAST
Ports: 1
Flow Directn: DOWN

Trim Number: 1 METAL 1"-4"
Cage Matl: 17-4PH SST
Retainer Matl: NONE
Bushing Matl: NONE
Seat Ring Matl: 416 SST
VALVE PLUG
Material: 416 SST
Guiding: CAGE
Balance: BALANCED
Shutoff Class: ANSI CLASS II
Port Size: 2-7/8" REST.
Characteristic: EQUAL PERCENT
Stem Material: 316 SST STR HDN
Stem Size: .5

Bonnet Style: STANDARD
Boss Size: 2 13/16
Packing: SINGLE TFE
Access: NONE
Bolt,Bonnet: B7 ALLOY STL BOLT
Pack.Flg: B7 ALLOY STL BOLT

Actuator: ELECTRIC
Size:
Travel:
Bench Set:
Push Down to: CLOSE

To Actuator:
Fails Valve:
Handwheel:

Positioner Type:
Input Signal:
Access:
Gauges:
Action:
Certification:

Controller Type:
Action:
Measure Elemnt:
Range:
Output:
Mounting:
Airset:
Mounting:

Transducer:
Input Signal:
Output Signal:
Action:
Mounting:
Airset:
Certifications:

Line In:
Line Out: 6 in SCH STD
Insulation:
Service Cond:
Process Fluid:

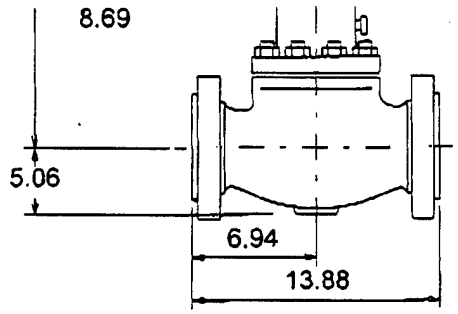
		MIN	NRM	MAX
T Satur	deg F		365.865	365.865
T	deg F		366.000	366.000
P1	psig		150.000	150.000
dP	psid		90.000	90.000
Qs	lb/h		30000.000	30000.000
Vlv LpA	dB(A)		101.6	84.2
Cs			182.171	182.171
C1			24.800	24.800

Maximum Flow Coefficient:
Actuator Thrust Required:

Unit Net Price:
1.42 Total Net Price:

FISHER **Fisher Controls** **General Meters & Controls Co.**

Purpose of drawing is for dimensional reference only. Total Calculated Assembly Weight: 154 lb



Unit of Measure = inches, scale=none. Envelope Dimensions are ± .25. Face to Face Tolerance Per ANSI.
4/15/94 Dimensions Certified Correct by Fisher Controls **FISHER-ROSEMOUNT**

ED 4 IN 150 RF	CUSTOMER: ARMY CORPS CUST REF #: TAG NO: SERIAL NO: FISHER REF #: ITEM NO: 1 REV: 1.1-0092-1049-0

GENERAL METERS & CONTROLS CO.

STANDARD TERMS AND CONDITIONS OF SALE

1. TERMS: Subject to the approval of Seller's Credit Department, terms are F.O.B. Seller's plant, net 30 days from date of Seller's invoice, except for export shipments for which other provisions for payment may be required by Seller. Should Buyer's financial responsibility be or become unsatisfactory to Seller, advance cash payments or security satisfactory to Seller may be required. If any payment owed to Seller hereunder is not paid when due, it shall bear interest, at Seller's option, of up to the maximum rate permitted by law from the date on which it is due until it is paid. The foregoing shall not relieve Buyer from the obligation to make payments to Seller at the time and in the manner specified. Seller reserves the right, among other remedies, either to terminate this contract or to suspend further deliveries under it in the event Buyer fails to pay for any one shipment when due. The prices specified are in U.S. currency, unless otherwise indicated, payable at Seller's offices.

2. PRICES: Unless otherwise specified by Seller, Seller's prices for the goods shall remain in effect for thirty (30) days from the date of Seller's quotation or acceptance of the order for the goods, whichever occurs first; provided an unconditional, complete authorization for the immediate manufacture and shipment of the goods pursuant to Seller's standard invoicing procedures is received and accepted by the Seller from the Buyer within such time period. After such thirty (30) day period, Seller shall have the right to revise the price of the goods up to Seller's price in effect for the goods at the time the order is released by Buyer and Seller to final manufacture and shipment; provided, however, that any such price revision for goods manufactured by the Seller shall not exceed seven percent (7%) during the six (6) month period following the date of Buyer's order or Seller's quotation, whichever occurs first. The price for any goods sold by Seller, but manufactured by others, shall be Seller's price in effect at the time of shipment to Buyer.

3. DELIVERY: All shipping dates are approximate and are based upon prompt receipt of all necessary information from Buyer to properly process the order.

4. EXCUSE OF PERFORMANCE: (a) Deliveries may be suspended by Seller, without liability in the event of: Act of God, war, riot, fire, explosion, accident, flood, sabotage; lack of or delays in obtaining adequate fuel, power, raw materials, componenets, labor, containers or manufacturing or transportation facilities; compliance with governmental requests, laws, regulations, order or actions; breakage or failure of machinery or apparatus; national defense requirements or any other event, whether or not of the class or kind enumerated herein, beyond the reasonable control of Seller, or in the event of labor trouble, strike, lockout or injunction (provided that Seller shall not be required to settle a labor dispute against its own best judgment); which event makes impracticable the manufacture or delivery of a shipment of the goods or of a material or component upon which the manufacture of the goods is dependent.

(b) If Seller determines that its ability to supply the total demand for the goods or obtain any or a sufficient quantity of material or component used directly or indirectly in the manufacture of the goods, is hindered, limited or made impracticable, Seller may allocate its available supply of the goods or such material or component (without obligation to acquire other supplies of any such goods, material, or component) among itself and its purchasers on such basis as Seller determines to be equitable without liability for any failure of performance which may result therefrom.

(c) Deliveries suspended or not made by reason of this section shall at Seller's option, either be cancelled or the delivery shall automatically be extended for a period equal to the suspension period, without liability, but this contract shall otherwise remain unaffected.

5. TERMINATION BY BUYER: Buyer may terminate its order for any or all of the goods covered by this contract, provided Seller is given reasonable advance notice of such termination and subject to payment to Seller of termination charges which shall include all costs and expenses already incurred or commitments made by Seller in connection with the processing, handling and fabrication of said goods, and a reasonable profit thereon. Seller's determination of such termination charges shall be conclusive.

6. LIMITED WARRANTY: Subject to Section 7 and unless otherwise expressly provided herein, Seller warrants title and that the goods manufactured by Seller will be free from defects in materials or workmanship under normal use and service until the expiration of the earlier of twelve (12) months from the date of initial operation or eighteen (18) months from the date of shipment by Seller. Resale goods shall carry only the warranty extended by the original manufacturer. If, within thirty (30) days after Buyer's discovery of any warranty defects, Buyer notifies Seller thereof in writing, Seller shall, at its option, promptly repair or replace F.O.B. point of manufacture, that portion of the goods found by Seller to be defective. Failure by Buyer to give such written notice within the applicable time period shall be deemed an absolute and unconditional waiver of Buyer's claim for such defects. Goods repaired and parts replaced during the warranty period shall be in warranty for the remainder of the original warranty period. This warranty is the only warranty made by Seller and can be amended only by a written instrument signed by an officer of Seller. Subject to this Section 6 and except as otherwise expressly provided in this contract, SELLER MAKES NO REPRESENTATION OR WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, AS TO MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE, OR ANY OTHER MATTER WITH RESPECT TO ANY OF THE GOODS.

7. LIMITATION OF LIABILITY: (a) BUYER'S EXCLUSIVE REMEDY SHALL BE FOR DAMAGES, AND SELLER'S TOTAL LIABILITY FOR ANY AND ALL LOSSES AND DAMAGES ARISING OUT OF ANY AND ALL CAUSES WHATSOEVER (WHETHER SUCH CAUSE BE BASED IN CONTRACT, INFRINGEMENT, NEGLIGENCE, STRICT LIABILITY, OTHER TORT OR OTHERWISE) SHALL IN NO EVENT EXCEED THE PURCHASE PRICE OF THE GOODS IN RESPECT OF WHICH SUCH CAUSE ARISES OR, AT SELLER'S OPTION, THE REPAIR OR REPLACEMENT OF SUCH GOODS, AND IN NO EVENT SHALL SELLER BE LIABLE FOR INCIDENTAL, CONSEQUENTIAL OR PUNITIVE DAMAGES RESULTING FROM ANY SUCH CAUSE. Seller shall not be liable for, and Buyer assumes liability for, all personal injury and property damage connected with the handling, transportation, possession, use, further manufacture, or resale of the goods. Neither transportation charges for the return of the goods nor any other costs or charges incurred by Buyer will be paid by Seller unless authorized in advance by Seller.

(b) If Seller furnishes technical or other advice to Buyer, whether or not at Buyer's request, with respect to Buyer's process or equipment, such advice shall be made in good faith, and Buyer assumes all risk of such advice and the results thereof.

8. PATENTS: Subject to Section 7, Seller warrants that any goods sold pursuant to this contract, or their use as provided below, except as are made specifically for Buyer according to Buyer's specifications, do not infringe any valid U.S. Patent in existence as of the date of delivery. This warranty is given upon condition that Buyer promptly notify Seller of any claim or suit involving Buyer in which such infringement is alleged, and if Seller is affected, that Buyer permit Seller to control completely the defense or compromise of any such allegation of infringement. Seller's warranty as to use only applies to infringements arising solely out of the inherent operation (i) of such goods, or (ii) of any combination of goods sold hereunder in a manner designed by Seller.

9. INSTALLATION: All equipment shall be installed by and at the expense of the Buyer.

10. TAXES: Any tax or governmental charge or increase in same hereafter becoming effective increasing the cost to Seller of producing, selling, or delivering the goods or of procuring materials used therein, and any tax now in effect or increase in same payable by the Seller because of the sale of the goods, such as Sales Tax, Use Tax, Retailer's Occupational Tax or Gross Receipts Tax may, at Seller's option, be added to the price herein specified.

11. PRŌVOX® COMPUTER PROGRAMS: These terms and conditions do not apply to PRŌVOX® Computer Programs and the goods sold hereunder do not include such programs. If PRŌVOX® Computer Programs are to be provided to Buyer for use in conjunction with goods purchased hereunder, such programs shall be used by Buyer only pursuant to Seller's standard license agreement.

12. NUCLEAR: Items for nuclear applications are subject to "Special Nuclear Terms of Sale" which must be executed by the necessary parties stipulated therein. The "Special Nuclear Terms of Sale" supplement these Terms and Conditions and prevail in any situations where there is a conflict.

13. COMPLIANCE WITH CERTAIN LAWS: Subject to Section 7 and unless otherwise expressly provided herein, the goods shall be produced in compliance with the requirements of the Fair Labor Standards Act of 1938, as amended, and Executive Order 11246, the provisions of which are incorporated herein by reference.

14. ASSIGNMENT: Buyer shall not (by operation of law or otherwise) assign its rights or delegate its performance hereunder without the prior written consent of Seller, and any attempted assignment or delegation without such consent shall be void.

15. MISCELLANEOUS: The validity, interpretation and performance of this contract and any dispute connected herewith shall be governed and construed in accordance with the laws of the State of Illinois. This contract constitutes the full understanding of the parties, a complete allocation of risks between them and a complete and exclusive statement of the terms and conditions of their agreement. No conditions, usage of trade, course of dealing or performance, understanding or agreement purporting to modify, vary, explain or supplement the terms or conditions of this contract shall be binding unless hereafter made in writing and signed by the party to be bound, and no modification shall be affected by the acknowledgment or acceptance of purchase order or shipping instruction forms containing terms or conditions at variance with or in addition to those set forth herein. No waiver by either Seller or Buyer with respect to any breach or default or of any right or remedy and no course of dealing, shall be deemed to constitute a continuing waiver of any other breach or default or of any other right or remedy, unless such waiver be expressed in writing signed by the party to be bound.

Appendix G - Bristol Babcock Quote for
Remote Control Instrumentation

Engineered
Instrumentation and
Control Systems

FLC Instruments, Inc.

1019 Airpark Drive
Sugar Grove, Illinois 60554
Phone: (708) 556-4477
FAX: (708) 556-4478

Regional Offices:
Alton, IL Phone: (618) 462-4756
Elkhorn, WI Phone: (414) 723-3495

May 11, 1994

USACERL, Energy Systems Division
P.O. Box 4005
2902 Newmark Drive
Champaign, Illinois 61820

Attn: Mr. Chris Dilks
Research Assistant

Subject: Remote Steam Pressure Control System,
Iowa Army Ammunition Depot, Middletown, Iowa

Reference: Estimating Proposal FLCI No. 40510

Dear Mr. Dilkes:

We are pleased to enclose the reference proposal for your use in estimating cost of the subject project.

As discussed, we have not included a personal computer, CRT and printer for the central location. The Bristol Data Concentrator contains an RS-232 port for connection to the PC.

Our proposal scope of word includes all software programming for the remote terminal units. The valve control algorithm will be pressure setpoint as a function of ambient temperature. The RTU I/O includes one (1) spare analog output and seven (7) spare discrete outputs as well as one spare I/O card slot.

We include all workstation Iconics software programming to provide remote control by operator, status displays and reports. Steam flow totals are included for daily and weekly flows at each location.

The Radio communications is proposed to be 450 mHz main channel telemetry and we include site survey and license assistance.

Not included are any towers or masts for antenna mounting.

Other details of our offering are in the text of our proposal.

Thank you for the opportunity to propose our equipment and services. Please call if you need further information or have any questions.

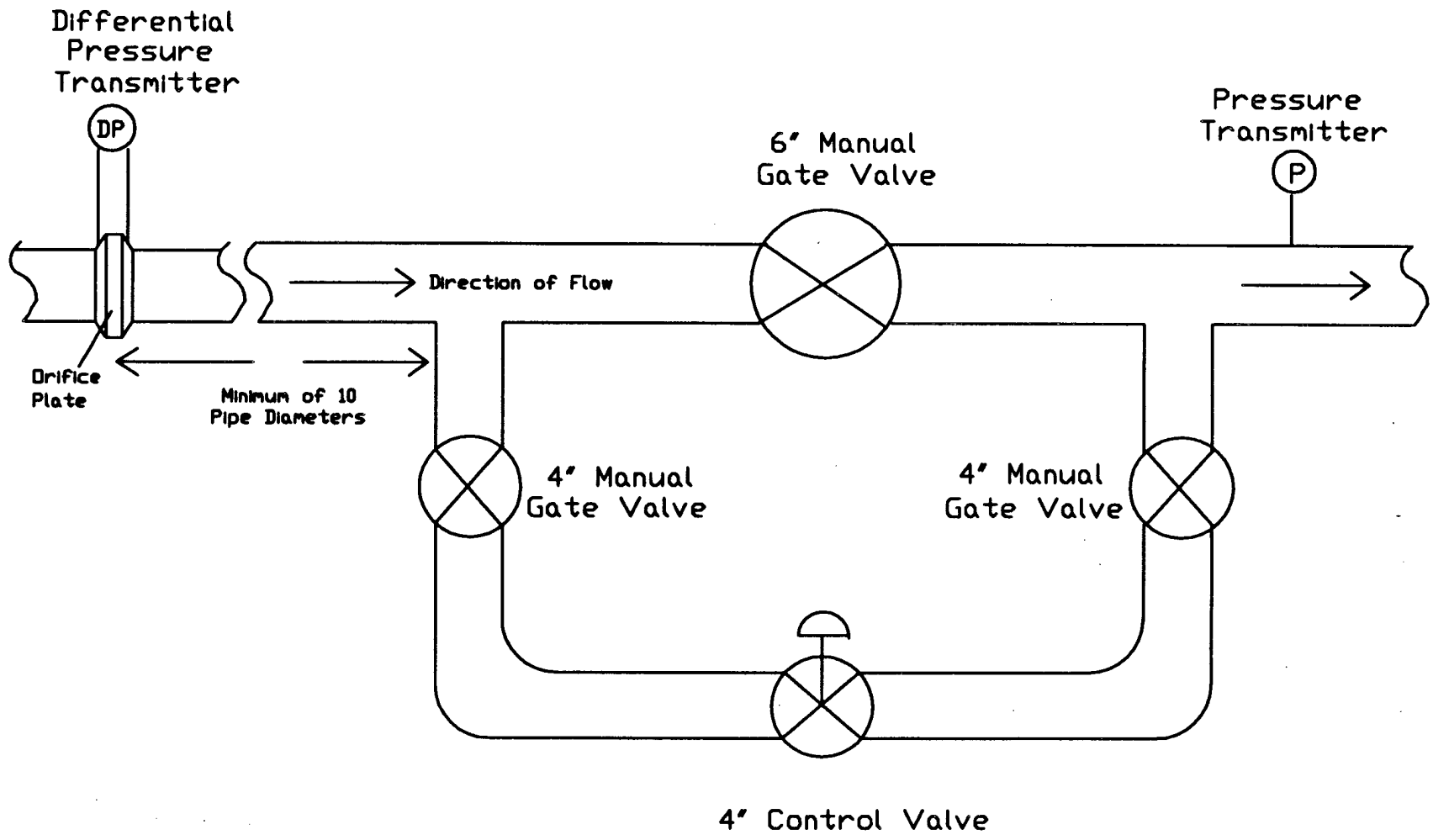
Very truly yours,

John R. Steinhoff

John R. Steinhoff
Vice President

JRS:dmb
enclosures
a:\quotes#2\40510L.doc
cc: Greg Hablutzel-FLC Alton

Pressure Reducing Station



US ARMY CORPS OF ENGINEERS

CONSTRUCTION ENGINEERING RESEARCH LABORATORY

PROJECT: REMOTE STEAM PRESSURE CONTROL SYSTEM

IOWA ARMY AMMUNITION DEPOT
MIDDLETOWN, IOWA

FLCI ESTIMATING PROPOSAL NO.: INST- 40510

Prepared by: FLC INSTRUMENTS, INC.
1019 Airpark Drive
Sugar Grove, Illinois 60554

(708) 556-4477

May 11, 1994

PROPOSAL ITEMS

EQUIPMENT

See attached Bill of Material.

ENGINEERING

All submittals/drawings, wiring diagrams, data sheets, specification sheets and instruction manuals called for under this contract will be prepared according to the specifications and FLC Instruments engineering standards. Up to five (5) sets will be provided. Additional copies available at $500.00 per set.

The following drawings and documents will be prepared by FLC Instruments:

A. Bill of Materials
B. Instrument Data Sheets
C. Catalog Cut Sheets
D. Interconnecting Wiring Diagrams
E. Panel Layout Drawings
F. Instrument Loop Diagrams
G. Software Descriptions of Programs

JOB SCHEDULING

Job scheduling is predicated on your return of the submittal within 60 days. Unless prior agreements dictate otherwise, no equipment orders will be placed until your written approval has been noted on the returned submittal set. Up to five (5) sets of the corrected submittal data will be returned to you for the correction of your copies, should revisions be required.

One (1) set of corrected reproducibles of record drawings will be provided upon your receipt of final acceptance of the instrument system provided, as described by this proposal.

Up to five (5) sets of System Manuals providing a complete description of equipment, operation, maintenance and service procedures, instructions and recommended parts list will be provided after our submittal has been approved. Additional copies available at $500.00 per set. Also included are five (5) sets of system disks for all program loads.

FACTORY TEST

Our proposal includes one (1) day factory acceptance test at FLC Instruments, Inc., Sugar Grove, IL.

WARRANTY

See attached FLC Instruments, Inc. "Terms and Conditions".

DELIVERY

A schedule will be provided.

EXTRA OR CHANGED WORK

When directed to do extra, reduced or changed work, FLC Instruments will prepare a proposal describing the revised work, the price addition or reduction, and the effect on delivery. We will not proceed with such work until authorized to do so in writing.

ACCEPTANCE

We shall consider our contract responsibility executed upon notification or completion of the calibration and commissioning of each individual instrumentation loop and payment in order for that portion of the work. A letter of installation, calibration, and commissioning completion will be submitted.

PRICE

The price for the proposed equipment and services is.....$92,745.00.

Optional Installation Supervision and Additional Start-up Assistance,
per Standard Man Day.....$640.00*

Note: See page 3 of this proposal for field services included in the price above.

***Plus Expenses:**

These include per diem, common carrier fares, cost of surface transportation and those costs directly related to the service call. Per diem will be billed at $125.00 per day, if overnight stay is required.

Mileage at $0.55/mile and expenses, as incurred, are in addition to the rates shown.

TERMS AND CONDITIONS OF SALE

Our standard terms and conditions are attached. They are modified, or supplemented for this proposal as follows:

Validity of proposal 60 days.

Freight: This proposal is based upon F.O.B. Sugar Grove, IL.

Terms: Net 30 days on all invoices.

This proposal specifically does not include:

1. Any installation of equipment.

2. Any electrical wiring or material pertaining to the installation of equipment.

3. Any interconnecting piping, fittings, valves, sleeves or other plumbing fixtures; and pneumatic or hydraulic piping external to the proposed equipment.

4. Any equipment not specifically listed on our "Bill of Material".

5. No permits, sales or use taxes are included in our price.

BILL OF MATERIAL

ITEM	QTY	DESCRIPTION
1	3	**Remote Terminal Unit:** Nema 4, 30"H X 24"W X 10"D enclosures with the following mounted and wired. a. Bristol Babcock Model RTU3310-10A-121-000-A001-600-B47E0-D200 Digital Process Controller. Specification Summary: D463SS-1a. Analog inputs (4), flow rate, valve position, ambient temperature and downstream pressure. Analog outputs (1) 4-20 mAdc for valve control. Discrete outputs (1) contact closure for remote shutdown, alarm, etc.. b. MDS UHF Model 4310, 5 watt data radio with 1200 BAUD modem. c. 115VAC to 12 vdc power supply for radio. d. Line noise filter e. AC line circuit breaker f. Converter concepts C65 battery back-up power supply, 120V, 60Hz to 24 vdc. g. Batteries for four hour back up of DPC 3310. h. Internal lamp and display receptacle. i. Heater/thermostat
2	3	Bristol Babcock Differential Pressure Transmitters for steam flow measurement. Model 2508-35B-XX2-212-220-010-100 with 3-valve, 316 S.S. manifold. Specification Summary: B225-61b.
3	3	Bristol Babcock Pressure Transmitter for downstream pressure measurement. Model 2508-15B-XX0-212-010-100 with 316 S.S. block and bleed valve and A100 2 position signal damping. Specification Summary: B225-60a.

4	3	Bristol Babcock Temperature Transmitters for ambient temperature measurement. Model 2508-41B-110-100 with 100 ohm platinum sensor Model 9742-10A-124-015 mounted on transmitter. Specification Summaries: B225-65a and B225-90a.
5	3	AGM Electronic Pot-to Current Transmitters for valve position. Mounted inside RTU enclosures.
6	1	**Data Concentrator Enclosure at Central Location:** Nema 12, 30"H X 24"W X 10"D enclosures with the following mounted and wired: a. Bristol Babcock Model DPC 3330-10A-520-100-A-246-9100-D200 Data Concentrator. Specification Summary: D456SS-Od b. MDS UHF Model 4310, 5 watt data radio with 1200 BAUD modem. c. 115 VAC to 12 vdc power supply for radio. d. Line noise filter. e. AC line circuit breaker. f. Sola 120VAC to 24 vdc power supply. g. Internal lamp and duplex receptacle.
7	3	Antenna for remote site, Proline PLC 456N, 7 1/2 db gain YAGI with 40 feet RG213/U coaxial cable connectors and antenna mounting hardware.
8	1	Antenna for Central location, Decibel Products Model DB420, 9 db gain omnidirectional antenna with 40 feet RG213/U coaxial cable, connectors and antenna mounting hardware.
9	1	ICONICS Genesis™ workstation software for operator interface via customer provided IBM compatible PC at central location. Specification Summary: D454SS-2a.

Engineered
Instrumentation and
Control Systems

FLC Instruments, Inc.

1019 Airpark Drive
Sugar Grove, Illinois 60554
Phone: (708) 556-4477
FAX: (708) 556-4478

Regional Offices:
Alton, IL Phone: (618) 462-4756
Elkhorn, WI Phone: (414) 723-3495

FLC INSTRUMENTS, INC.

MANUFACTURERS & REPRESENTATIVES

NORTHERN ILLINOIS & NORTHWESTERN INDIANA

FLC Instruments, Inc. offers full service, Systems House capabilities from engineering design of your control system to panel fabrication, calibration, and commissioning. We also offer complete service contracts and repair services to keep your system operating properly for years.

In addition we represent the following manufacturers:

AGM ELECTRONICS	- Digital and analog signal conditioners and alarms.
BRISTOL BABCOCK	- Full line of instrumentation for measurement, recording, and process control including digital supervisory control, and data acquisition. Authorized Bristol Babcock Systems House.
DATA-LINC	- Modules for data transmission over existing wiring (AC/DC power lines, PBX, phone). Moves data across sliding contacts, slip rings, etc. Analog, digital, RS232, 422, 485.
EAZY	- Black Box™ Data distribution hardware, switches, surge protectors, LAN hardware.
FLC SYSTEMS GROUP	- Integrated control systems, project management, concept design, application engineering, software configuration, panel fabrication, commissioning and service.
ICONICS	- Genesis personal computer based software for process control and data acquisition (SCADA).

QEI, INC.	- Quindar remote monitoring and control products. FSK tone, analog and digital scanners.
ROYCE INSTRUMENT	- On-line analyzers, pH, ORP, DO and suspended solids. Sludge blanket level detection.
SCOTT AVIATION	- Detection and alarm system for combustible and toxic gases and flammable liquids.
SPARLING INSTRUMENTS, INC.	- Flow and level measurement, control and monitoring devices. Propeller, magnetic and ultrasonic.

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FLC INSTRUMENTS, INC. PROFILE

FLC INSTRUMENTS, INC. FACILITIES & CAPABILITIES

Headquarters and Sales Office:	1019 Airpark Drive Sugar Grove, Illinois 60554 Employees: 25
Engineering and Manufacturing Facilities:	15,0000 Sq. Ft. Building in Aero Corporate Park
Field Sales Offices:	Alton, Illinois Elkhorn, Wisconsin Appleton, Wisconsin

Founded in 1980, FLC Instruments, Inc. is composed of:

A. Systems Group -

Manufacturer of Process Control, Supervisory Control and Data Acquisition Systems for the industrial and municipal utilities markets.

B. Sales Group -

Sales representation for manufacturers of Process Control instrumentation applied in the industrial and municipal utilities markets.

Our continued controlled growth since 1980 has resulted in FLC Instruments, Inc. being listed in INC Magazine in 1988 as number 381 of the top 500 most rapidly growing privately held companies in the United States -- a measure based upon five consecutive years of consistent growth.

FLC Instruments' engineering staff consists of engineers averaging over 14 years of experience each. Our engineers and technicians are trained in the application and service of various manufacturing equipment and application software. FLC Instruments has been an authorized Systems House for Bristol Babcock Instruments and Systems since 1983.

The company has been built around the strength and depth of the engineers in the Systems Group. Our engineers have a wide range of supervisory process control experience in industrial and municipal applications, and we have produced complex analog and digital systems.

Some major clients are:

City of Evanston, IL
City of Florissant, MO
Granite City Division, National Steel
Great Lakes Gas Transmission Co.
City of Highland Park, IL
IBM, Boulder, CO
IBM, Manassas, VA
Illini Carrier Gas Pipeline
Metropolitan Water Reclamation District of Greater Chicago
Metropolitan St. Louis Sewer District
Milwaukee Metropolitan Sewerage District
City of Parkersburg, WV
City of Racine, WI

FLC Instruments, Inc. does not manufacture individual instruments, it purchases instrumentation equipment from various major instrumentation vendors and provides the end user with an integrated engineered solution to their process control and data acquisition requirements. We assemble and test each control system in our facility prior to shipment to jobsite and then provide the required field services to ensure proper installation, calibration and commissioning, training and follow-up service and maintenance.

FLC Instruments has invested in the latest state of the art design and drafting equipment. Our engineering documents are produced on word processors and computer aided drafting machines (CAD).

FLC Instruments, Inc. and its employees are members of the following professional organizations:

Instrument Society of America (ISA)
American Water Works Association (AWWA)
Water Pollution Control Federation (WPCF)
Society of Tribologists and Lubrication Engineers (STLE)
American Society of Testing Materials (ASTM)
Institute of Electrical and Electronic Engineers (IEEE)
Technical Association of the Pulp and Paper Industry (TAPPI)
Paper Industry Management Association (PIMA)

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FLC SYSTEMS
STANDARD SCHEDULE OF FEES

The following rates, terms and conditions apply to FLC Instruments, Inc. (FLC) Services:

Principals - Project Work	$125.00/Hr.
Project Managers	$112.50/Hr.
Sr. Engineers	$95.00/Hr.
Software Development Engineers	$95.00/Hr.
Engineers II/Sr. Engineering Technicians	$80.00/Hr.
Demand Service by Technicians	$80.00/Hr.
Contract Service by Technicians	$60.00/Hr.
CAD Operators	$58.50/Hr.
Word Processors, Secretaries, Editors	$45.00/Hr.

Note: All rates include use of equipment.

1. Rates are computed portal-to-portal and require 4 hours minimum.
2. Mileage at $0.55/mile and expenses, as incurred, are in addition to the rates shown.
3. Per Diem (meals and lodgings) $125.00/Day, when overnight stay is required.
4. Any parts used during service are supplied at list prices.
5. Rates apply Monday through Friday 8 a.m. to 5 p.m. 1½ times rates applies all other times, but Sundays and Holidays where rate will be 2 times above rates.

ENGINEER OR SPECIALIST

Where engineering evaluations and/or recommendations are needed, or where factory level capability is required to perform complete service or repair, or supervise special tests.

DEMAND SERVICE

Emergency service, maintenance, new product start-up, or any service requested for a specific time period.

CONTRACT SERVICE

Service that is scheduled in advance and at the convenience of FLC, service is to be performed at regular intervals. Rates may be a fixed rate, including labor, mileage and all expenses, negotiated on annual basis with each customer and billed as a lump sum at each visit.

EXPENSES

These include per diem, common carrier fares, cost of surface transportation and those costs directly related to the service call. Per diem will be billed at $125.00 per day. These rates could vary depending upon locations that are extremely costly, including resort areas such as Miami, Hawaii, Alaska, etc. At these locations expenses may be charged as incurred.

Terms: Net 30 Days
All sales and services subject to our Warranty Policy.
Prices subject to change without notice.

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FLC PANEL MANUFACTURING AND SYSTEMS PRACTICES

WIRE MARKING - Each wire is tagged with Brady machine generated shrink wrap. The number indicated on the wire indicates the number of the wire on the blueprint as well as the page on which it can be found. This not only facilitates reading the tag on the wire, but also locating it in the prints. In addition to this, the tag stays on the wire by using the shrink wrap method as opposed to simply using numbered tape. All of these measures simplify troubleshooting or future changes to be made.

MISC. MARKING - All components, terminal strips, and pushbuttons are marked indicating the components and the page of the prints they can be found.

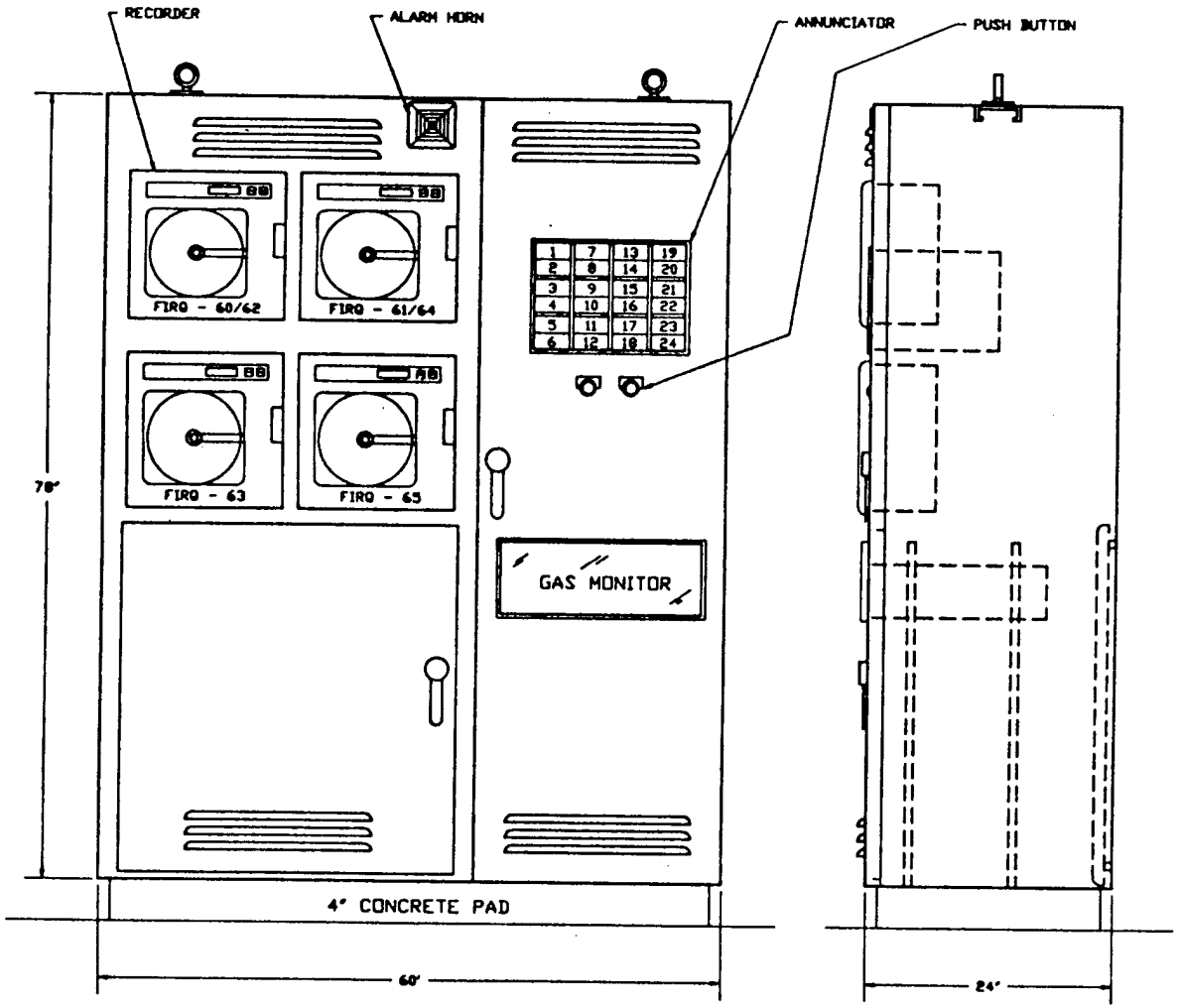
HIGH QUALITY EQUIPMENT USED - Allen Bradley pushbuttons, Hoffman enclosures, Panduit wireway, Square-D terminal blocks, 1000V MTW wire, Red Lion meters, etc. If specific products are desired we will adhere to the specification.

HIGH QUALITY PRINTS AND DOCUMENTATION - All blueprints are generated on an AutoCAD system and panels are provided with full documentation which is clearly and logically designed. On complex systems, we provide operation and maintenance manuals, recommended spare parts lists, control narratives and software documentation as required by the end user.

EXPERIENCE - Our engineers average fourteen years of experience in their respective fields. We can satisfy your needs ranging from individual instrumentation hardware or small field measurement devices to complete integrated control systems such as sophisticated microprocessor or mini-computer based distributed control or supervisory systems.

TESTING AND QUALITY CONTROL - Our engineers test and retest all completed panels and systems. Our testing consists of simulated analog and digital input and output testing, dynamic system mimicking, and real time simulation of the process to be utilized. This extensive testing assures you of a smoother more efficient start up.

FIELD SERVICE - FLC's staff of experienced factory-trained field service technicians provide on-site services. They are equipped with both the expertise and the test and calibration equipment to insure that your analog and digital instrumentation systems operate in an accurate and reliable manner.



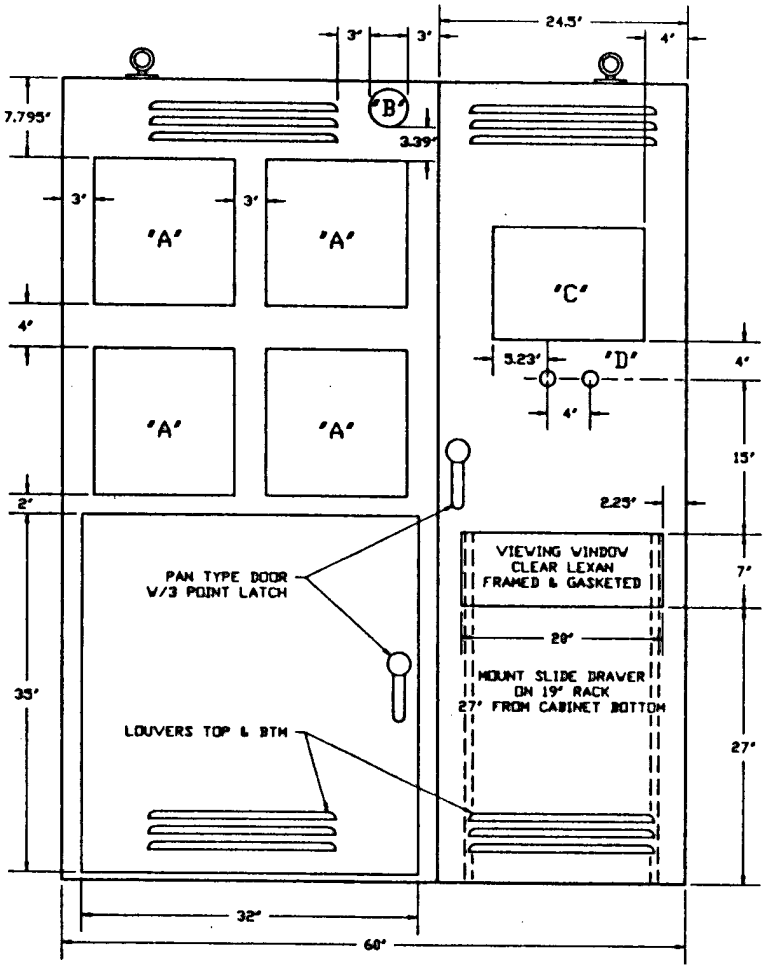
AISH-70 (GAS MONITOR) MOUNTED ON SLIDE DRAWER.

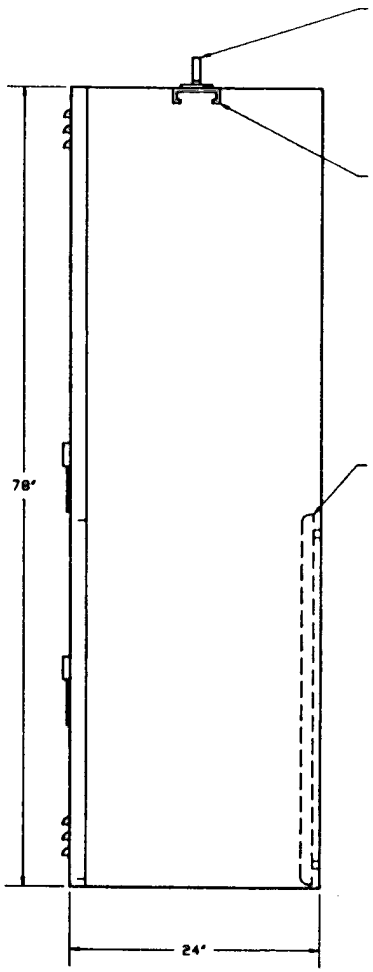
NOTE:	ANNUNCIATOR
WINDOW	LEGEND
1	GAS COMPRESSOR NO. 1 FAIL
2	GAS COMPRESSOR NO. 2 FAIL
3	GAS COMPRESSOR NO. 3 FAIL
4	RECIRCULATING PUMP NO. 1 FAIL
5	RECIRCULATING PUMP NO. 2 FAIL
6	RECIRCULATING PUMP NO. 3 FAIL
7	WASTE GAS BURNER FAIL
8	COMBUSTIBLE GAS BUILDING 1 - UPPER LEVEL
9	COMBUSTIBLE GAS BUILDING 2 - UPPER LEVEL
10	COMBUSTIBLE GAS BUILDING 3 - UPPER LEVEL
11	COMBUSTIBLE GAS BUILDING 1 - LOWER LEVEL
12	COMBUSTIBLE GAS BUILDING 2 - LOWER LEVEL
13	COMBUSTIBLE GAS BUILDING 3 - LOWER LEVEL
14	COMBUSTIBLE GAS COMPRESSOR ROOM
15	COMBUSTIBLE GAS GENERATOR ROOM
16	BUILDING NO. 1 - HVAC ALARM
17	BUILDING NO. 2 - HVAC ALARM
18	BUILDING NO. 3 - HVAC ALARM
19	(SPARE - LEAVE BLANK)
20	(SPARE - LEAVE BLANK)
21	(SPARE - LEAVE BLANK)
22	(SPARE - LEAVE BLANK)
23	(SPARE - LEAVE BLACK)
24	(SPARE - LEAVE BLACK)

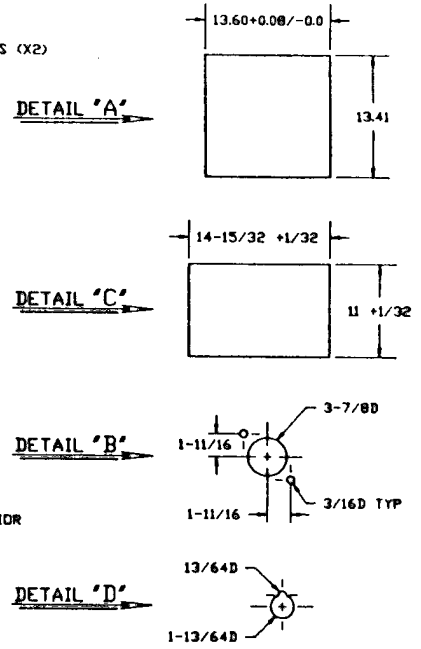
FLC Instruments Inc.

1771 Mallette Rd., Aurora, IL 60505 (312) 851-7665

DATE 07-13-88	DWG. TITLE HINSDALE SANITARY DISTRICT 1987 SEWAGE TREATMENT PLANT IMPROVEMENTS		
DRAWN G.C			
AS BUILT	DWG. DESCRIPTION DISGESTER METERING PANEL LAYOUT		
SCALE NTS	CHECKED	APPROVED	REV. DATE 1-18-89
DWG. NO. 806-4022-PA001		SHT. 1 OF 1	REV. NO. 2







NOTES - 1. OPEN BOTTOM CONSTRUCTION, ANGLE IRON FRAME (2" X 2" X 1/8") MOUNTING HOLES AS REQUIRED.

2. MATERIAL- 1/8" STEEL

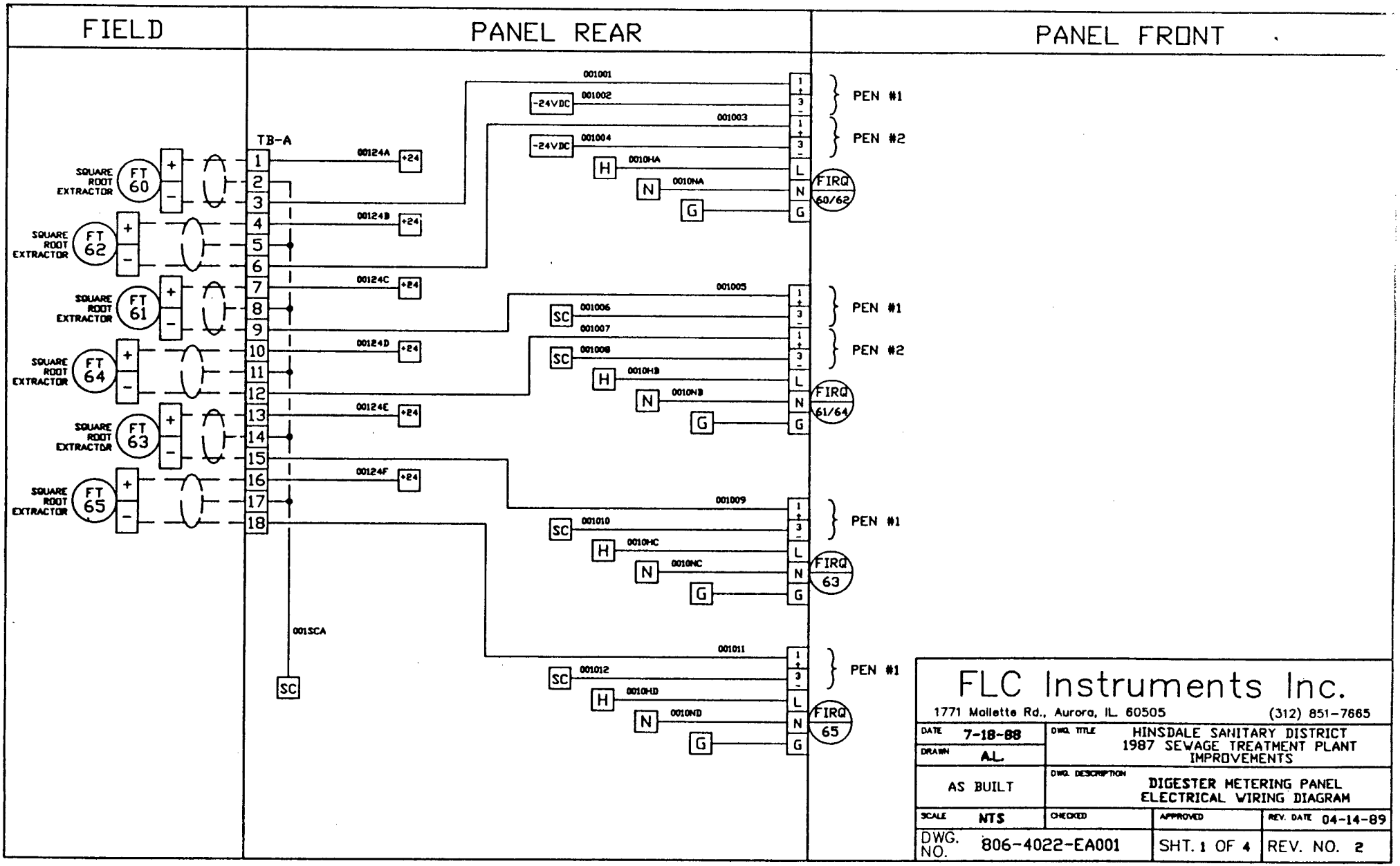
3. COLOR- (EXTERNAL) ANSI 61 GRAY (INTERNAL) BAKED WHT ENAMEL

4. STIFFENERS AS REQUIRED.

FLC Instruments Inc.

1771 Mallette Rd., Aurora, IL. 60505 (312) 851-7665

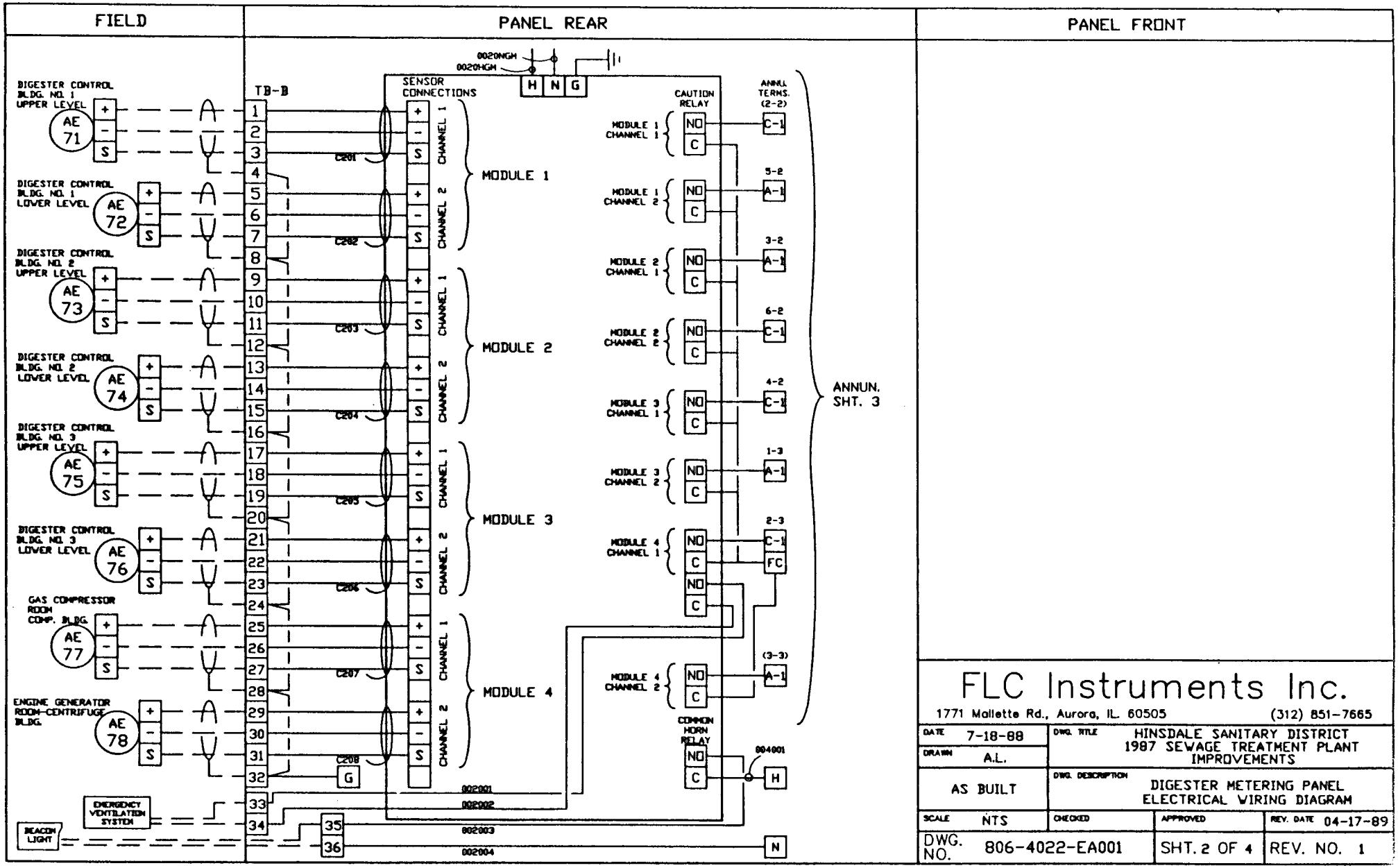
DATE 07-13-88	DWG. TITLE HINSDALE SANITARY DISTRICT 1987 SEWAGE TREATMENT PLANT IMPROVEMENTS		
DRAWN G.C			
AS BUILT	DWG. DESCRIPTION DIGESTER METERING MECHANICAL LAYOUT		
SCALE NTS	CHECKED	APPROVED	REV. DATE 1-12-89
DWG. NO. 806-4022-MA001		SHT. 1 OF 1	REV. NO. 1

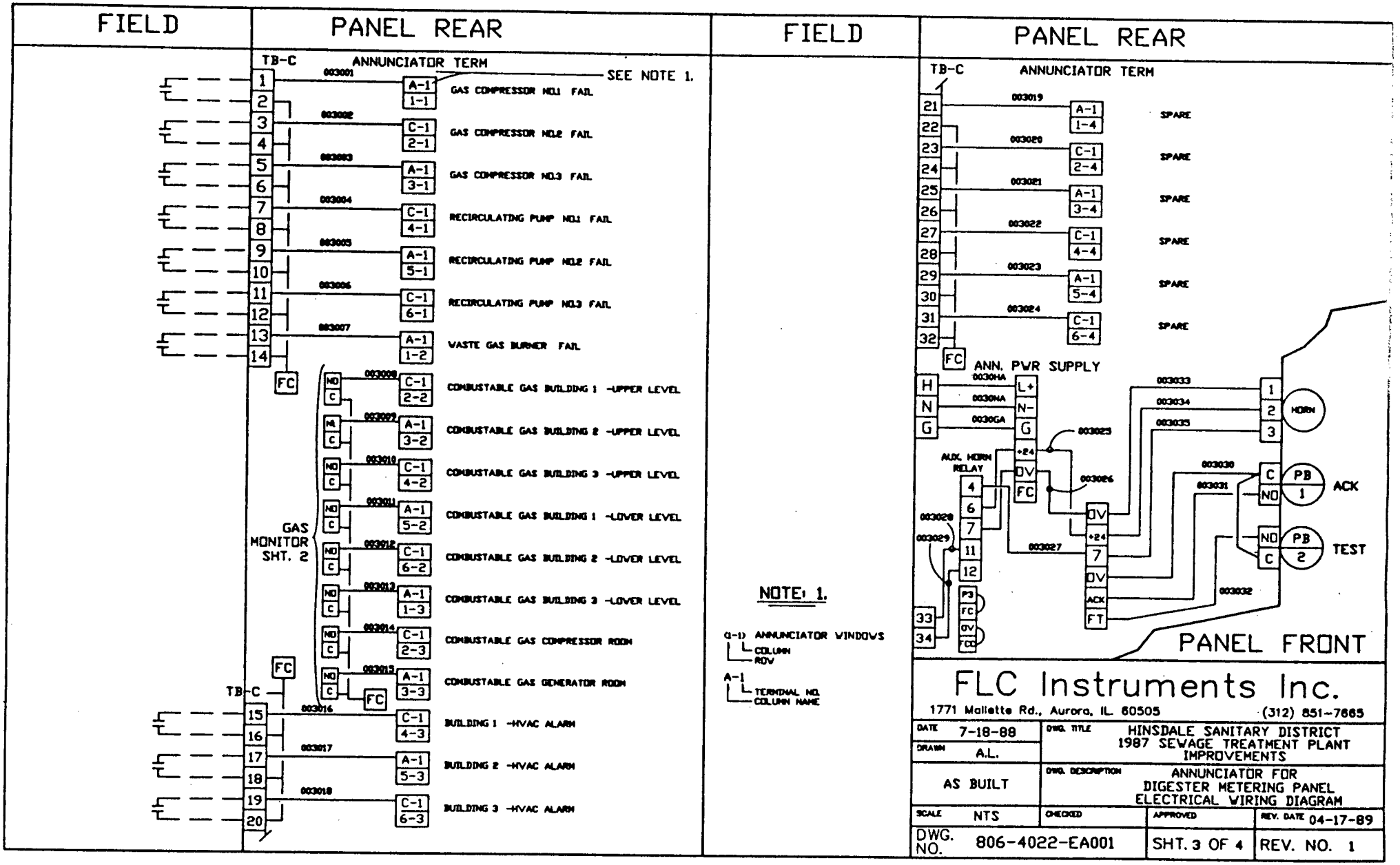


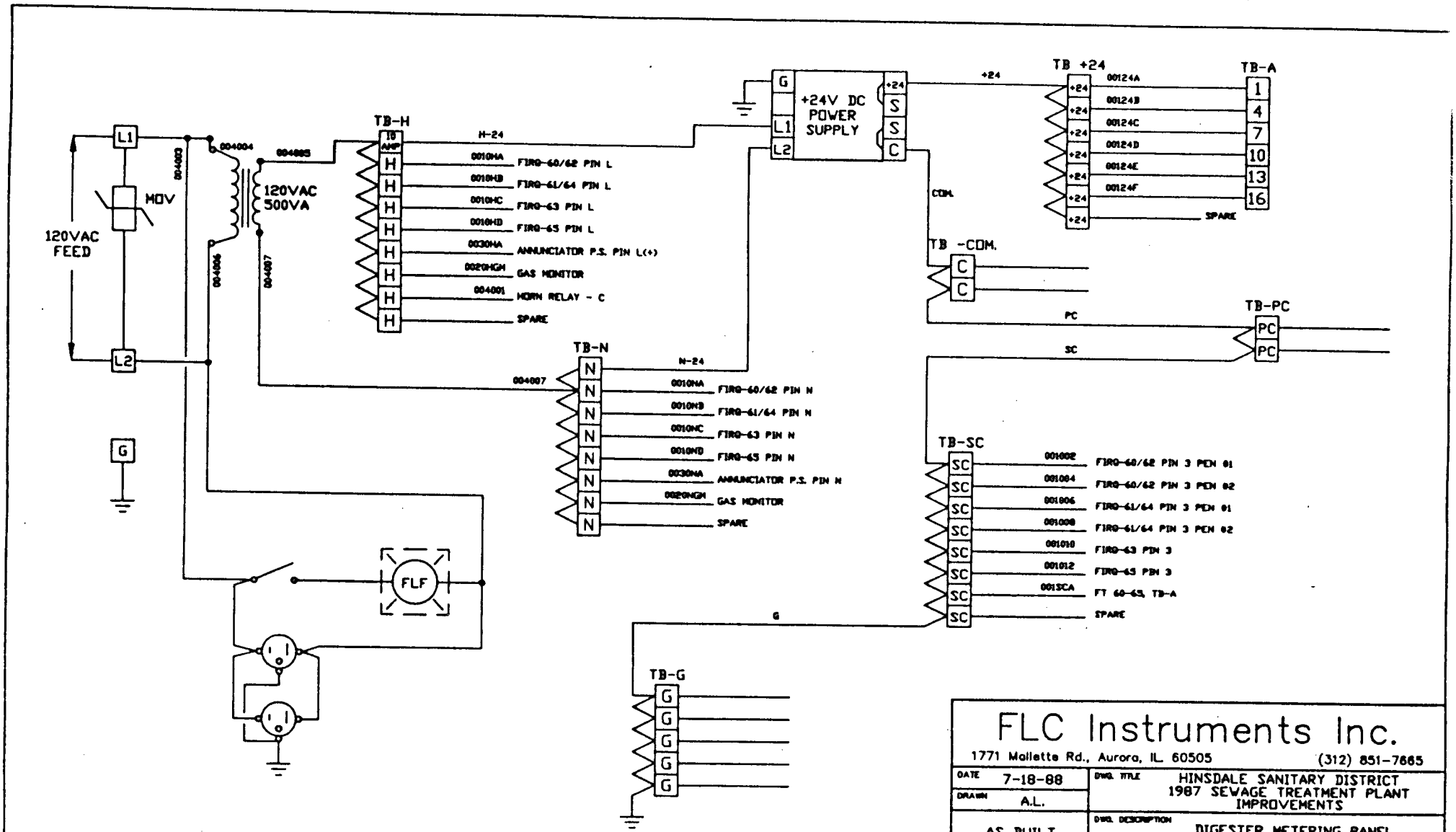
FLC Instruments Inc.

1771 Mallette Rd., Aurora, IL 60505 (312) 851-7665

DATE 7-18-88	DWG. TITLE HINSDALE SANITARY DISTRICT 1987 SEWAGE TREATMENT PLANT IMPROVEMENTS		
DRAWN A.L.			
AS BUILT	DWG. DESCRIPTION DIGESTER METERING PANEL ELECTRICAL WIRING DIAGRAM		
SCALE NTS	CHECKED	APPROVED	REV. DATE 04-14-89
DWG. NO. 806-4022-EA001		SHT. 1 OF 4	REV. NO. 2


FIELD
PANEL REAR
PANEL FRONT
TB-B
SENSOR CONNECTIONS
CAUTION RELAY
ANNUL TERMS. (2-2)
BIGESTER CONTROL BLDG. NO. 1 UPPER LEVEL
AE 71
BIGESTER CONTROL BLDG. NO. 1 LOWER LEVEL
AE 72
BIGESTER CONTROL BLDG. NO. 2 UPPER LEVEL
AE 73
BIGESTER CONTROL BLDG. NO. 2 LOWER LEVEL
AE 74
BIGESTER CONTROL BLDG. NO. 3 UPPER LEVEL
AE 75
BIGESTER CONTROL BLDG. NO. 3 LOWER LEVEL
AE 76
GAS COMPRESSOR ROOM COMP. BLDG.
AE 77
ENGINE GENERATOR ROOM-CENTRIFUGE BLDG.
AE 78
EMERGENCY VENTILATION SYSTEM
BEACON LIGHT
0020NGM
0020HGM
H N G
MODULE 1
MODULE 2
MODULE 3
MODULE 4
CHANNEL 1
CHANNEL 2
C201
C202
C203
C204
C205
C206
C207
C208
G
002001
002002
002003
002004
004001
H
N
NO
C
FC
ANNUN. SHT. 3
FLC Instruments Inc.
1771 Mallette Rd., Aurora, IL. 60505
(312) 851-7665
DATE 7-18-88
DRAWN A.L.
AS BUILT
SCALE NTS
DWG. TITLE HINSDALE SANITARY DISTRICT 1987 SEWAGE TREATMENT PLANT IMPROVEMENTS
DWG. DESCRIPTION DIGESTER METERING PANEL ELECTRICAL WIRING DIAGRAM
CHECKED
APPROVED
REV. DATE 04-17-89
DWG. NO. 806-4022-EA001
SHT. 2 OF 4
REV. NO. 1


FIELD
PANEL REAR
TB-C
ANNUNCIATOR TERM
SEE NOTE 1.
003001
A-1
1-1
GAS COMPRESSOR NO.1 FAIL
003002
C-1
2-1
GAS COMPRESSOR NO.2 FAIL
003003
A-1
3-1
GAS COMPRESSOR NO.3 FAIL
003004
C-1
4-1
RECIRCULATING PUMP NO.1 FAIL
003005
A-1
5-1
RECIRCULATING PUMP NO.2 FAIL
003006
C-1
6-1
RECIRCULATING PUMP NO.3 FAIL
003007
A-1
1-2
WASTE GAS BURNER FAIL
FC
GAS MONITOR SHT. 2
003008
C-1
2-2
COMBUSTABLE GAS BUILDING 1 -UPPER LEVEL
003009
A-1
3-2
COMBUSTABLE GAS BUILDING 2 -UPPER LEVEL
003010
C-1
4-2
COMBUSTABLE GAS BUILDING 3 -UPPER LEVEL
003011
A-1
5-2
COMBUSTABLE GAS BUILDING 1 -LOWER LEVEL
003012
C-1
6-2
COMBUSTABLE GAS BUILDING 2 -LOWER LEVEL
003013
A-1
1-3
COMBUSTABLE GAS BUILDING 3 -LOWER LEVEL
003014
C-1
2-3
COMBUSTABLE GAS COMPRESSOR ROOM
003015
A-1
3-3
COMBUSTABLE GAS GENERATOR ROOM
TB-C
003016
C-1
4-3
BUILDING 1 -HVAC ALARM
003017
A-1
5-3
BUILDING 2 -HVAC ALARM
003018
C-1
6-3
BUILDING 3 -HVAC ALARM
NOTE: 1.
C-1 ANNUNCIATOR WINDOWS
COLUMN
ROW
A-1
TERMINAL NO.
COLUMN NAME
FIELD
PANEL REAR
TB-C
ANNUNCIATOR TERM
003019
A-1
1-4
SPARE
003020
C-1
2-4
SPARE
003021
A-1
3-4
SPARE
003022
C-1
4-4
SPARE
003023
A-1
5-4
SPARE
003024
C-1
6-4
SPARE
FC
ANN. PWR SUPPLY
003040
003041
003042
L+
N-
G
+24
OV
FC
AUX. HORN RELAY
003025
003026
003027
003028
003029
003033
003034
003035
HORN
003030
003031
003032
PB 1
ACK
PB 2
TEST
PANEL FRONT
FLC Instruments Inc.
1771 Mallette Rd., Aurora, IL 60505
(312) 851-7665
DATE 7-18-88
DRAWN A.L.
AS BUILT
SCALE NTS
DWG. TITLE HINSDALE SANITARY DISTRICT 1987 SEWAGE TREATMENT PLANT IMPROVEMENTS
DWG. DESCRIPTION ANNUNCIATOR FOR DIGESTER METERING PANEL ELECTRICAL WIRING DIAGRAM
CHECKED
APPROVED
REV. DATE 04-17-89
DWG. NO. 806-4022-EA001
SHT. 3 OF 4
REV. NO. 1



FLC Instruments Inc.

1771 Mallette Rd., Aurora, IL 60505 (312) 851-7665

DATE 7-18-88	DWG. TITLE HINSDALE SANITARY DISTRICT 1987 SEWAGE TREATMENT PLANT IMPROVEMENTS		
DRAWN A.L.			
AS BUILT	DWG. DESCRIPTION DIGESTER METERING PANEL POWER DISTRIBUTION		
SCALE NTS	CHECKED	APPROVED	REV. DATE 04-17-89
DWG. NO. 806-4022-EA001		SHT. 4 OF 4	REV. NO. 2

SPECIFICATION SUMMARY

B225-61b

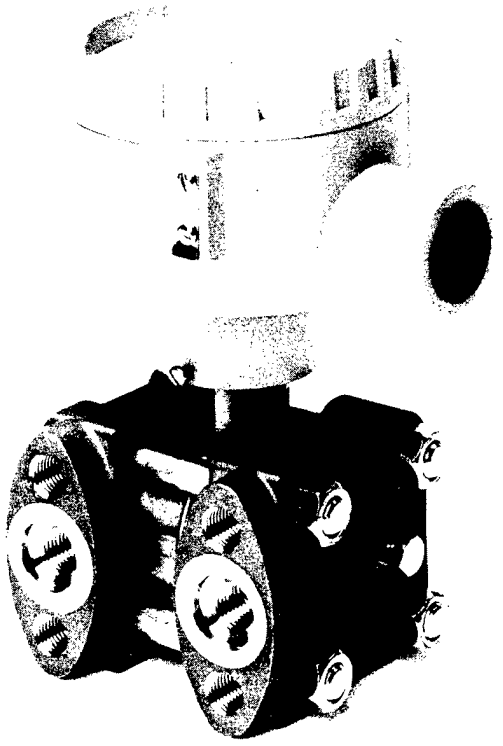
SIGNATURE 2508-35B
DIFFERENTIAL PRESSURE TRANSMITTER

FEATURES

- o Adjustable ranges
- o 0.15% accuracy
- o Two year warranty standard
- o Explosion-proof electronic housing
- o Wide range of exotic materials for diaphragms and flanges, in addition to stainless steel
- o Local indicator option, linear or in engineering units
- o Process wetted parts meet N.A.C.E. specification MR0175-91

The 2508-35B is a compact, high performance transmitter designed to accurately measure differential pressure and transmit a proportional 4-20 mA signal. The 2508-35B has an initial cost that makes repair by total replacement a truly practical concept. Spare parts inventory and maintenance training are thus eliminated.

The 35B is an adjustable range transmitter that is calibrated at the factory to a specific measurement range. Input ranges covering 17 inches H_2O through 300 PSID are available. Zero and span adjustments are available inside the electronic housing for making minor "touch up" adjustments in the field. The 35B has an electronic function board that permits a 6:1 span adjustment capability and zero elevation and suppression.



Bristol Babcock's 2508 Differential Pressure Transmitter

OPERATION

The sensor module provides the process connections. These connections expose one side of the process diaphragms to the high and low pressure respectively. The 35B contains a micromachined transduction element, fabricated using integrated circuit technology, to sense input pressure. This sensing technology combines the mechanical aspects of silicon, which is literally as strong as steel and hysteresis free, with the inherent semiconductor and electronic properties of an integrated circuit. The sensor consists of an internal silicon diaphragm into which piezoresistive strain gauge resistors are diffused, then interconnected to form a pressure sensitive Wheatstone bridge. The outer process diaphragms are hydraulically connected to the silicon diaphragm using a suitable fill fluid. When the sensor is energized, by applying pressure to the process diaphragms, the silicon diaphragm deflects proportionally to the differential pressure, resulting in an electrical output change proportional to the input differential pressure. Because of the single crystal nature of the silicon diaphragm, linearity is excellent and pressure hysteresis is essentially immeasurable.

Bristol Babcock

SIGNATURE 2508-35B
DIFFERENTIAL PRESSURE TRANSMITTER

SPECIFICATION SUMMARY

B225-61b

FUNCTIONAL SPECIFICATIONS

- **Service:**
  Liquid, gas or vapor

- **Input ranges:**

Lower Range Limit	Upper Range Limit	Maximum Static Pressure (PSI) Note 1	Leak Pressure (PSI) Note 1	Rupture Pressure (PSI) Note 1
-100" H_2O	100 " H_2O	2000/200	4000/400	6000/600
-300" H_2O	300" H_2O	2000/200	4000/400	6000/600
-ATM	25 PSID	2000/200	4000/400	6000/600
-ATM	100 PSID	2000	4000	6000
-ATM	300 PSID	2000	4000	6000

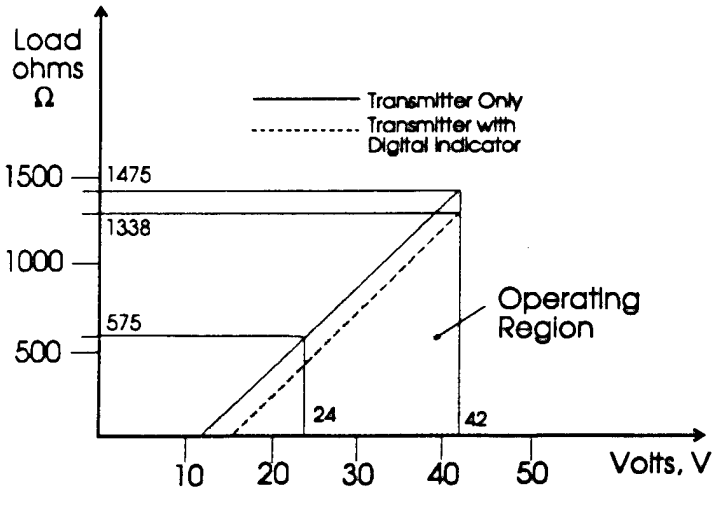
Note 1: Metal/Kynar respective ratings

- **Power supply:**
  24V dc nominal
  12.5V minimum at transmitter
  15.25V dc minimum with Local Digital Indicator option
  36V dc maximum at transmitter
  42V dc with external load specified
  Reverse polarity protected

  The maximum loop resistance can be determined as shown below:

  $$R\ Loop\ (maximum) = \frac{Vsupply - 12.5}{.02}\ ohms$$

  Maximum loop capacitance = 0.01 µf



- **Output:**
  Two wire analog: 4-20 mA dc proportional to differential pressure
  Current limited: 35 mA maximum
  Minimum current: 2 mA to 3.5 mA

- **Zero adjustment:**
  Up to 500% L.R.L. zero suppression, and 600% L.R.L zero elevation via DIP switches
  Internal fine adjustment via zero pot

- **Span adjustment:**
  6:1 span adjustment through DIP switches
  Internal fine adjustment via span pot

- **Overpressure limits:**
  To full static rating on either side

- **Damping:**
  Time constant: (time for a 63% change in output with a 100% input change)
  Damping ON: 0.15 sec. +/- 25% time constant via move -able jumper
  Damping OFF: Less than 10 ms
  Time to steady output after application of 24 volts supply with constant pressure: 10 ms maximum

PERFORMANCE SPECIFICATIONS

- **Accuracy:**
  ±0.15% of calibrated span. Includes linearity, hysteresis, and repeatability
  ±0.25% of calibrated span for Range 13
  Up to ±1% for elevated zero

- **Stability:**
  ±0.25% of URL per six months at reference conditions.

- **Overpressure effect (at maximum operating pressure):**
  ±0.2% of URL

- **Static pressure effect (Total including zero and span):**
  ±1% of URL/1000 PSI for range 22 and 23
  ± 0.3%/URL/1000 PSI typical for ranges 13, 14 & 20,
  ±0.5% maximum

- **Ambient temperature effect (total including zero and span):**
  ±0.015% of URL per °F from -25 to 75°F
  ±0.01% of URL per °F from 75 to 185°F
  ±0.02% of URL per °F for Range 13

SIGNATURE 2508-35B
DIFFERENTIAL PRESSURE TRANSMITTER

SPECIFICATION SUMMARY

B225-61b

- **Power supply effect:**
  ±0.005% of URL per volt change

- **Ripple and Noise:**
  Per ISA 50.1, section 4.6
  Digital meter = ±1 count max

PHYSICAL SPECIFICATIONS

- **Diaphragm material:**
  316 stainless steel
  Hastelloy C
  Monel
  Tantalum

- **Process flange:**
  316 stainless steel
  Hastelloy C
  Monel
  Kynar
  316 stainless steel (for remote seals only)

- **Flange bolt material:**
  316 stainless steel

- **Fill fluids:**
  DC 200 Silicone oil
  Fluorolube

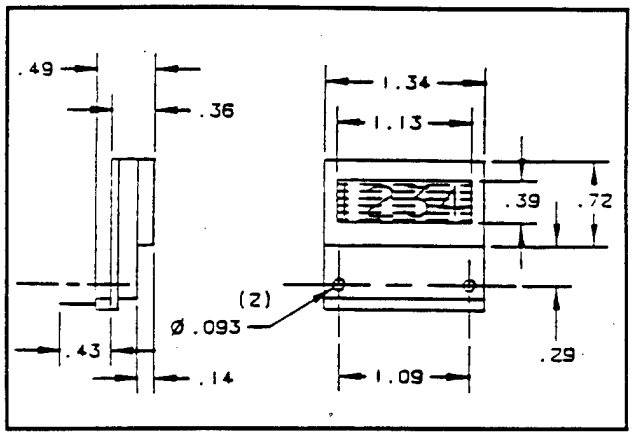
- **Process connections:**
  1/4" NPT on flanges
  1/2" NPT with connection blocks

- **Electrical connections:**
  1/2" NPT conduit connection

- **Housing material and rating:**
  Low copper aluminum with epoxy paint, NEMA 4X

- **Local Indication:**
  3-1/2 Digit LCD Meter: Linear (0 to 100%), or in engineering units
  Size of digits = 0.3"
  Size of window = 1.13" (L) x 0.39" (W)
  Green backlight
  Zero: Can be adjusted approx. 20% of span
  Polarity: Automatic (-) displayed

- **Weight:**
  Standard: 5.5 lbs.
  With meter option: 6 lbs.



Local Indication - 3-1/2 digit LCD meter

ENVIRONMENTAL SPECIFICATIONS

- **Temperature limits:**
  Wet end:
  -40° to 220° F (-40° to104° C) - DC 200 fill
  0° to 220° F (-17.8° to 104° C) - Fluorolube fill
  Electronics:
  -25° to 185° F (-32° to 85° C) standard
  -22° to 176° F (-30° to 80° C) with meter option
  Storage:
  -40° to 212° F (-40° to 100° C) standard
  -40° to 176° F (-40° to 80° C) with meter option

- **Humidity limits:**
  15 - 95% RH to 60°C max
  15 - 50% RH to 85°C max
  Local Indicator (Digital) = 15 - 95% RH to 60°C max
  15 - 50% RH to 80°C max

- **Mounting position effect:**
  ±1.5" H_2O maximum which can be calibrated out

- **Vibration effect:**
  Less than ±.1% of URL for 15 to 1600 Hz at 1G in any axis with damping ON

- **EMI effect:**
  ±1% of URL at 10 V/M from 20 to 500 MHz (SAMA PMC-33-1C) (covers on and wiring in grounded conduit) (for units without local indication)

- **Surge Protection: Bipolar, differential surge:**
  1000 watts for 1 ms - without local indicator
  Additional surge protection provided by purchased auxiliary surge protector

SIGNATURE 2508-35B
DIFFERENTIAL PRESSURE TRANSMITTER

SPECIFICATION SUMMARY B225-61b

- **Hazardous locations:**
  - Factory Mutual (FM) Approval
  - Explosion Proof Class I, Div 1, Groups B, C, D
  - Non Incendive Class I, Div 2, Groups A, B, C, D
  - Dust Ignition Proof Class II, Division 1, Groups E, F, G
  - Suitable for Class III (ignitable fiber), Div 1, indoor and outdoor (NEMA 4X)
  - CSA Certified for Hazardous Locations for Explosion Proof/Dust Ignition Proof -
  - Class I, Div I, Groups B, C, and D;
  - Class II, Div I, Groups E, F, and G;
  - Class III , "CSA Encl 4"

MODEL NUMBER SPECIFICATIONS

2508-35B-ABC-DEF-GHJ-KMN-PQR

AB Input Ranges
- 0-17" to 0-100" H_2O 13
- 0-50" to 0-300" H_2O 14
- 0-4.2 to 0-25 PSID 20
- 0-17 to 0-100 PSID 22
- 0-50 to 0-300 PSID 23

C Static Pressure Rating
- 2000 PSI 2
- 200 PSI (Kynar flanges only) 4

D Diaphragm Material
- 316 SS 2
- Hastelloy C 3
- Monel 4
- Tantalum 5

E Filling Media
- Silicone DC 200 1
- Fluorolube 2

F Function Board
- Adjustable 2

G Flange Material
- 316 SS 2
- Hastelloy C 3
- Monel 4
- Kynar (Note 1) 5
- 316 SS (for Remote Seals only) 6

H Flange Bolt Material
- 316 Stainless steel 2
- 316 Stainless steel (for Kynar flanges only) 3

J Manifold Material (Footballs) (Note2)
- None 0
- 316 SS 2
- Hastelloy C 3
- Monel 4

K Local Indication
- None 0
- 3 1/2 digit LCD meter 1

M Mounting Bracket
- None 0
- Universal 2" pipe mount 1

NP Certification
- None 00
- FM Exp. Proof / NI / DI Proof 01
- CSA Exp. Proof / DI Proof 02

QR 00

Note1: Selection G5 is only available for ranges AB-13, 14 & 20

Note 2: Footballs are required for use with 3-valve manifolds listed below.

Accessories & Options:

	P/N
Manifold only:	391142-01-1
Manifold with pipe mount:	391142-02-0
Transient Protector	388630-01-9

Remote Seals: Refer to spec. summary B225-3a

Bristol Babcock

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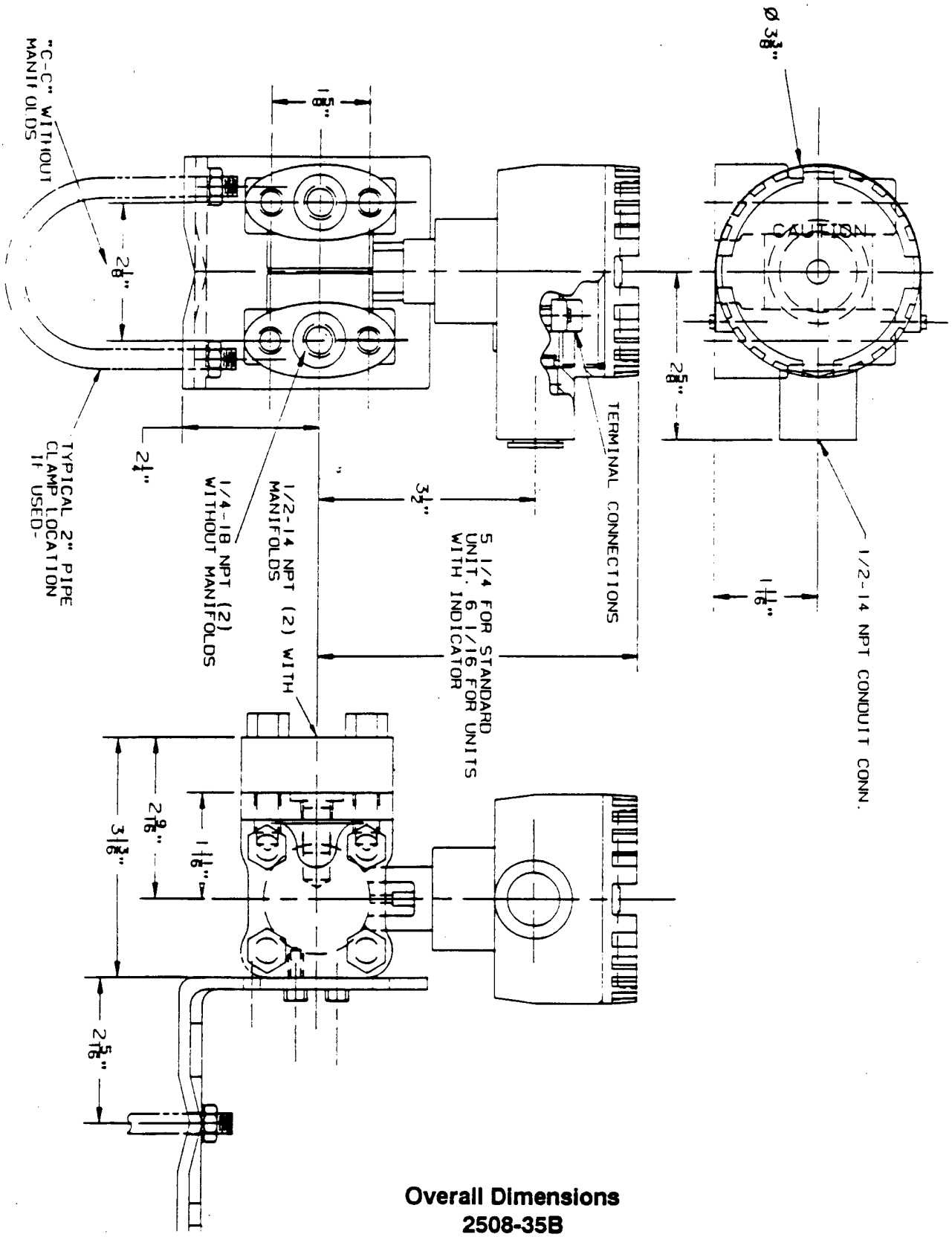
Rev. 8/93

Printed in the U.S.

SIGNATURE 2508-35B
DIFFERENTIAL PRESSURE TRANSMITTER

SPECIFICATION SUMMARY

B225-61b

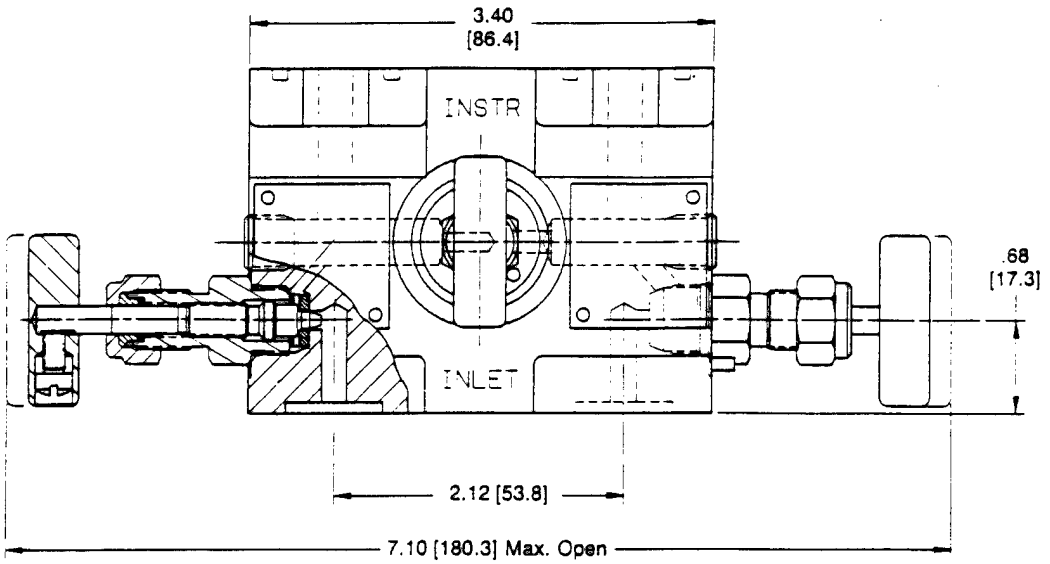


Overall Dimensions
2508-35B

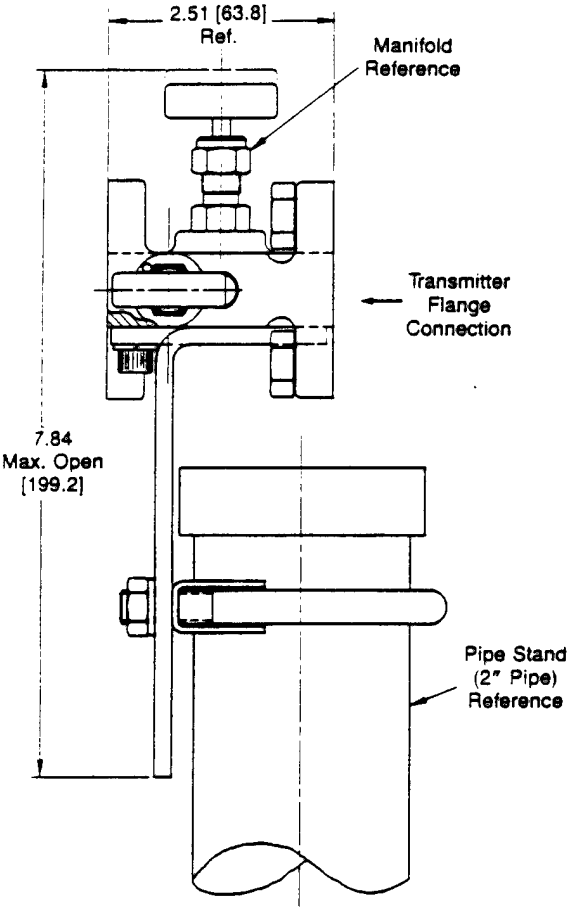
SIGNATURE 2508-35B
DIFFERENTIAL PRESSURE TRANSMITTER

SPECIFICATION SUMMARY

B225-61b

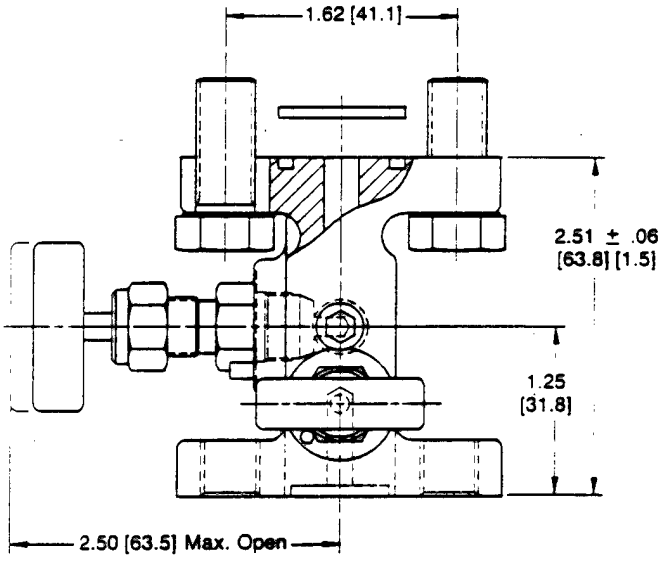


MANIFOLD DIMENSIONS



MANIFOLD WITH PIPE MOUNT

SIDE VIEW



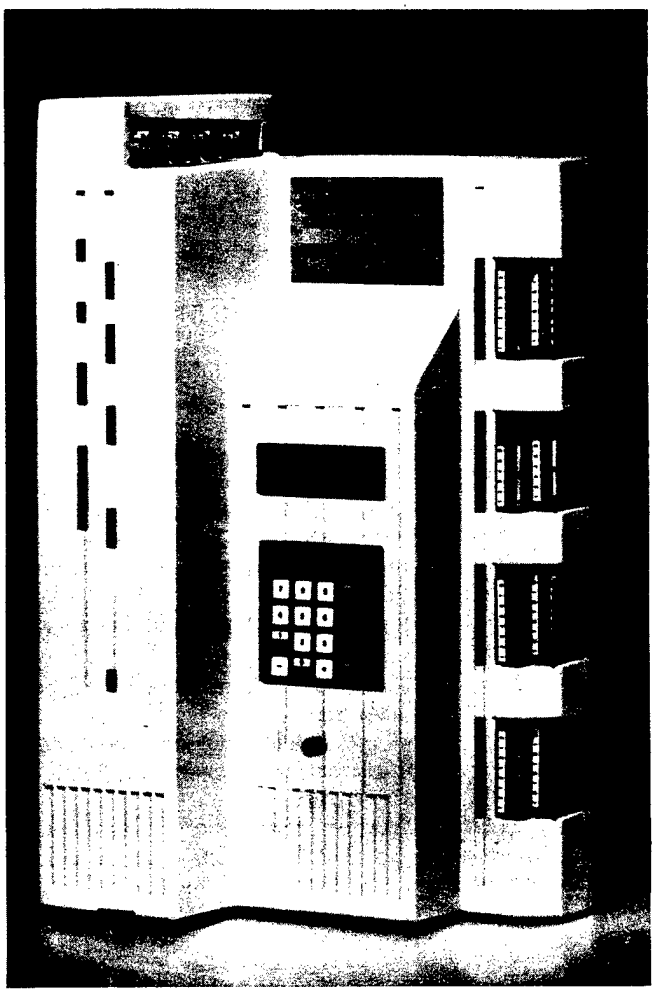
SPECIFICATION SUMMARY

D463SS-1a

NETWORK 3000

MODEL RTU 3310
SMALL ACCOL REMOTE TERMINAL UNIT

The RTU 3310 is an intelligent RTU fully compatible with Bristol Babcock's Network 3000. It is designed for those applications requiring a compact platform and low power consumption but also the full measurement and control programmability provided by ACCOL.



APPLICATIONS

To meet varying demands from many customers for a small programmable RTU, the RTU 3310 is designed for Class I, Division 2 hazardous locations and will operate over a -40° C to 70° C range. I/O is totally flexible. Up to four DPC 3330 series I/O cards can be installed in an RTU 3310. The most appropriate applications of this product include:

- o Automated Well Testing
- o Injection Well Control
- o Pump Off Control
- o Flow Computer/Meter Corrector
- o Meter Station Automation
- o Water Pump/Lift Station Control
- o Small remote process units
- o Autoclave control
- o Multi-loop controller

FEATURES

- o Fully programmable via ACCOL
- o Standard panel-mounting package
- o Operating temperature range: -40° C to 70° C
- o Class I, Division 2 design
- o Four serial ports (2 - RS232; 2- RS485)
- o Flexible I/O system: uses up to four 3330 I/O cards
- o Pluggable (quick disconnect) I/O terminations
- o Low power consumption
- o 12 Vdc or 24 Vdc nominal power input

OPTIONS

- o 4 x 20 Liquid crystal display with keypad
- o Nema 4 enclosure
- o Solar power package
- o Integral private line/switched network modem
- o Fiber optic data highway
- o Remote I/O - RIO 3331
- o Radio communication package
- o Mass terminal connectors on I/O cards with cables to DIN rail-mounting termination panels including high isolation panels

PROCESSING POWER

- o Processor: 16 bit CMOS 186XL microprocessor
- o Speed: 12 MHz
- o Firmware EPROM: 512K bytes
- o Optional application ACCOL EPROM: 64K bytes
- o RAM: 128K, 384K bytes
- o Real time clock: DS1287 accurate to one second per day
- o RAM battery back-up: 4000 hours minimum
- o 6 diagnostic LEDs
- o Idle LED
- o Watchdog LED
- o Watchdog timer, relay, and contact connections
- o Address DIP switch for network address (range: 1-127)

Bristol Babcock

RTU 3310
SMALL ACCOL REMOTE TERMINAL UNIT

SPECIFICATION SUMMARY D463 SS-1a

COMMUNICATION CAPABILITY

- 2 serial communication ports standard
  - Port A: RS232 only
  - Port B: RS485, optional modem, smart transmitter interface, or radio delay interface
- 2 additional ports optional
  - Port C: RS232 only
  - Port D: RS485 only
- 9-pin "D" connector for each port
- Media: multiconductor cable
- Cable length (at 9600 baud): 50 feet (RS232), 2000 feet (RS485);
  at 187.5 K baud: 1000 feet (RS485), 5000 feet (fiber)
- Multidrop: 32 nodes using RS485
- Point-to-point: RS232
- Asynchronous communication on all ports
- Synchronous communications on two ports (B&D)
- Asynchronous baud rates, selectable per port: 300, 1200, 2400, 4800, 9600, and 19200
- Asynchronous cold download baud rates:
  Ports A&C - fixed at 9600 baud
  Ports B&D - switch selectable (1200, 2400, 4800, 9600, 19200, 38400)
- Synchronous baud rate: 187.5 k (multidrop: RS485; point-to-point, only, for fiber optic
- Program downloading/uploading can be accomplished via synchronous or asynchronous communication

Typical applications: While port configuration is determined by the ACCOL program, port "A" is typically used for a local operator lap-top computer while port "B" is the SCADA network communication port. Other ports can be interfaced to additional networks or serial devices such as chromatographs and printers.

Modems

- Optional built-in modem connects to port B
- Modem baud rate: 300 or 1200, selectable per modem
- Three types of modems available:
  - Private line modem for leased lines or radio keying
  - Switched network modem for auto-dial/auto-answer
  - Fiber optic modem

Refer to specification summaries D461SS-2, D461SS-3, D461SS-4

Transmitter Interface Board (TIB)

- Optional, integral, plug-in board connects to port B
- Allows up to five 3508 smart transmitters to function as slaves to an RTU 3310
- Communicates at 1200 baud
- Polling speed: one transmitter per second
- Provides 24 volt loop power required by the 3508 (for 24 V 3310's only)

Refer to specificaiton summary D461SS-6

Radio Delay Interface Board (RDI)

- Radio and satellite communication delay board
- Optional, integral, plug-in board connects to port B
- Provides RS232 interface to an external radio modem or transciever
- Three timing functions available:
  - Leading Edge Delay (RTS-to-CTS Delay)
  - Trailing Edge Delay
  - Carrier Time Out

Refer to specification summary D461SS-5

COMMUNICATION PROTOCOLS

BSAP

- Bristol Standard Asynchronous Protocol
- ISO standard 1745/2111/2629
- Used to network Bristol products, including the SLC 3755, RTU 3310, DPC 3330, DPC 3335, RIO 3331, GFC 3308, and 3508 smart transmitters
- Local addressing: 127 nodes
- Global addressing: 32,767 nodes (via pass-through nodes)
- Hierarchy: 5 levels
- Contention scheme: Polled
- Programming: via standard master and slave ACCOL software modules

Refer to specification summary D454SS-6a

ASCII

- Simple ASCII with selectable start, stop, parity, and word formats
- Used for communication with RTU 3301's and peripheral devices such as computers, printers, graphic terminals, displays, and hand-held terminals
- Input and output
- Programming: standard ACCOL Logger module uses a complete set of format commands for message configuration, handshaking, display formatting, and printed report formatting

Other Protocols

- Allen Bradley PLC-2, standard
- Modbus, including Daniel Solarflow Plus and 2500 variations, standard
- Adept protocol, optional
- Columbia Natural Gas (ANSI 3.28), optional
- El Paso Natural Gas, standard
- Protocols are selectable on a per-port basis; an RTU 3310 can use multiple protocols (on different ports) simultaneously
- Several others also available
- Protocols are available on option custom protocol PROM

RTU 3310
SMALL ACCOL
REMOTE TERMINAL UNIT

SPECIFICATION SUMMARY D463 SS-1a

ENVIRONMENTAL SUITABILITY

The RTU 3310 is Factory Mutual certified, meets SAMA specifications for vibration, and meets IEEE-472/C37.90 surge protection criteria.

- o Operating temperature: -40° C to 70° C
- o Display/keypad: -20°C to 70°C
- o Low Level AI Board: 0°C to 70°C
- o High Speed AI Board: -20°C to 70°C
- o Storage Temperature: -40°C to 85°C
- o Relative Humidity: 5% to 95% noncondensing
- o RFI Susceptibility: Per SAMA standard PMC 33.1-1978, using field of 10 V/m from 20 MHz to 500 MHz
- o Vibration: Rated for field mount applications
  15 - 150 Hz @ 9.8 m/s² (1G) constant acceleration
  150 - 2000 Hz @ 4.9 m/s² (.5G) constant acceleration
- o Cooling: not required (natural convection)
- o NEMA rating: standard package not rated, but similar to NEMA 1
- o Approval: Factory Mutal certified as nonincendive for Class I, Division 2, Groups A-D installations
- o Dimensions: Refer to diagram
- o Weight: approximately 11 pounds with all cards installed, standard package

POWER REQUIREMENTS

- o Two voltage input ranges are available:
  12 volt: 9.0 to 15.0 Vdc
  24 volt: 22.0 to 28.0 Vdc
- o Maximum input noise and ripple: 2.0 volts, peak-to-peak

Power requirements by card or board assembly:

	Watts	Amps at 24 Vdc
CPU Board	1.40	0.058
Multi-Function Board (2 ports)	0.80	0.033
Multi-Function Board (4 ports)	1.00	0.042
Display/Keypad (local)	0.15	0.006
AI Board	0.44	0.018
AO Board	0.68	0.028
DI Board with LED	0.15	0.006
DI Board w/o LED	0.04	0.002
DO Board with LED	0.15	0.006
DO Board w/o LED	0.04	0.002
HSC Board with LED	0.22	0.009
HSC Board w/o LED	0.12	0.005
Low Level Board	1.40	0.058
HSAI Board	1.40	0.058
DO Relay Board w/LED	0.10	0.004
DO Relay Board w/o LED	0.04	0.002
C.B.O. Board	4.50	0.190
HWSTI Board	2.20	0.090
Modem	0.63	0.026
RDI Board	0.10	0.004
TIB Board	0.73	0.030

Note: The above figures do not include loop power. To account for the additional power draw of external devices such as transmitters, add the following to each point:

	Watts	Amps at 24 Vdc per input point
DI Board	0.12	0.005
HSC Board	0.12	0.005
DO Relay Board	0.25	0.010
AI Board	0.50	0.020
AO Board	0.50	0.020
HWSTI Board	0.30	0.012

SOFTWARE CONFIGURABILITY

The RTU 3310 uses ACCOL II, Bristol's high-level, modular process control language and is fully user configurable. ACCOL II features:

- o 90 high-level modules (algorithms)
- o 23 calculator module functions
- o 12 programming statements ("sequence extensions")
- o Multitasking: 127 tasks per RTU 3310
- o Task execution intervals: 0.02 to 5400 seconds or continuous, selectable per task
- o 9999 ACCOL modules per task
- o Analog (32 bit floating point), discrete (on/off) and string variables
- o Alarm/Exception reporting: state for logical values, four limits and two deadbands for analog values
- o Alarm/Event message storage: up to 4096 messages in RAM; 16 bytes per message
- o Data base storage: Data arrays: 4 bytes per stored value; up to 32 K bytes per array. Storage arrays: 12 values per 64 byte record; up to 256 K bytes of array space

Refer to specification summary D454SS-5a

SOFTWARE PACKAGES

The following software packages are pertinant to the RTU 3310:

ACCOL II Interactive Compiler (AIC)-Provides a fill-in-the-blanks menu system for configuration of ACCOL II programs. Includes on-line modification, linking, program downloading, and a documenter.

ACCOL II Batch Compiler (ABC)-Allows ACCOL II program creation and modification using a text editor. Useful in conjunction with the AIC.

Toolkit-A menu-driven, on-line software debug tool and hardware/communication diagnostic program.

RTU 3310
SMALL ACCOL
REMOTE TERMINAL UNIT

SPECIFICATION SUMMARY

D463 SS-1a

Universal Operator Interface (UOI) - Provides a customizable, menu-driven operator interface to an RTU 3310. Collects on-line, historical and audit trail data for storage and reporting.

NOTE: The off-line programs require DOS/IBM PC or VAX/VMS compatible. The on-line programs require DOS/IBM PC or VAX/VMS with Enterprise server.

Genesis-Provides a comprehensive PC-based operator interface for an RTU 3310 or network of RTU 3310s; provides color graphic displays, alarm reporting, printed reports, and historical data base.

Enterprise-Provides a comprehensive, multi-user operator interface for a network of RTU 3310's. VAX/VMS compatible. Suitable for large systems with up to 64,000 data points. (32,000 analog points, max.; 32,000 logical points, max.)

I/O ADAPTABILITY

The RTU 3310 provides interfacing to a wide variety of wiring present in measurement and process control systems. All the "standard" signal ranges are included. Four I/O slots are available; any combination of I/O cards can be used.

SPECIFICATIONS COMMON TO ALL I/O

- Pluggable terminal blocks
- Screw compression terminations accommodate up to 12 AWG wire
- 24 Vdc loop power available at terminations (not available in 12 Vdc powered units)
- Hardware selectable ranges/options
- Single boards include both terminations and interfacing electronics
- Surge protection meets IEEE 472-1974 and C37.90-1978 (revision, 1983)

ANALOG INPUTS

- 4 board types are available
- Differential inputs
- 12 bit A/D converter per board
- Conversion time: 200 µs
- Accuracy (all ranges):
  - 0.1% at 25° C
  - 0.2% over -20° C to 70° C
  - 0.3% over -40° C to 70° C
- Input filtering: single pole 50 msec time constant: 300 msec to 0.1% of input value
- Setting time: 18 µs to 0.01%
- Software filtering: fully programmable in ACCOL II
- Input sampling: depends on ACCOL task interval (0.02 to 5400 seconds)
- Surge protection

Board Code	Input Quantity	Input Range	Input Impedance	Common Mode Voltage	Surge Protection
1	4	0-10 Vdc	150 K ohms	+2 V, -12 V	• 39 Vdc
2	4	1-5 Vdc	150 K ohms	+5 V, -10 V	• 39 Vdc
		4-20 mA	250 ohms	+5 V, -10 V	• 39 Vdc
3	4	0-10 Vdc	2 Meg ohms	180 V	•180 Vdc
4	4	1-5 Vdc	2 Meg ohms	180 V	•180 Vdc
		4-20 mA	250 ohms	180 V	•180 Vdc

1-5 Vdc/4-20 mA selectable per point

ANALOG OUTPUTS

- 2 board types are available
- 12 bit D/A converter per board
- Accuracy (all ranges):
  - 0.1% at 25° C
  - 0.2% over -20° C to 70° C
  - 0.3% over -40° C to 70° C
- Surge protection: 15 V transorbs between analog output and analog common; 39 V MOVs between analog common and chassis ground
- Signal conditioning: 100 µs time constant for 1-5 Vdc/4-20 mA outputs; 6.5 µs time constant for 0-10V outputs Update interval: Software configurable (ACCOL task interval, 0.02 to 5400 seconds).

Board Code	Output Quantity	Output Range	Impedance
6	2	0-10 Vdc	5 mA source
7	2	1-5 Vdc	5 mA source
		4-20 mA	0 to 650 ohms

1-5 Vdc/4-20 mA selectable per point

LOW LEVEL INPUTS

- Operating Range: 0° C to 70° C
- 4 inputs per board
- All ranges selectable per point
- 14-bit A/D via successive approximation
- 16-bit on board microprocessor
- 32 K bytes EPROM
- 32 K bytes RAM

INPUT TYPES

Thermocouples	Range
B	100 to 1800° C
E	-270 to 1000° C
R	-50 to 1720° C
S	-50 to 1760° C
J	-210 to 1200° C
K	-270 to 1372° C
T	-270 to 400° C

RTU 3310
SMALL ACCOL REMOTE TERMINAL UNIT

SPECIFICATION SUMMARY

D463 SS-1a

RTD
100 Ω Platinum Din 43670 - 220 to 850°C

VOLTAGE
±10mV

ACCURACY
See Table below

INPUT RESISTANCE
10 Meg Ohms

SIGNAL CONDITIONING
50 ms time constant

ISOLATION-COMMON MODE
500 V peak w/isolation amplifiers

SURGE PROTECTION
IEEE 472-1974
C37.90-1978

Thermocouples		Resolution	25°C	Accuracy 0°C to +70°C
B	100 to 200°C	2.0°C	•8°C	• 16°C
	200 to 390°C	1.0°C	•4°C	• 8°C
	390 to 840°C	0.5°C	•2°C	• 4°C
	840 to 1800°C	0.2°C	•1°C	• 2°C
E	-270 to -260°C	1.0°C	•3°C	• 6°C
	-260 to -225°C	0.25°C	•1°C	• 2°C
	-225 to -200°C	0.08°C	•.75°C	• 1.5°C
	-200 to 1000°C	0.09°C	•.5°C	• 1°C
R	-50 to +50°C	0.4°C	•2°C	• 4°C
	50 to 1720°C	0.17°C	•1°C	• 2°C
S	-50 to +50°C	0.37°C	•2°C	• 4°C
	50 to 1760°C	0.18°C	•1°C	• 2°C
J	-210 to 191°C	0.08°C	•.75°C	• 1.5°C
	-190 to 1200°C	0.11°C	•.5°C	• 1°C
K	-270 to -261°C	2°C	•5°C	• 10°C
	-260 to 246°C	0.56°C	•2°C	• 4°C
	-245 to 180°C	0.25°C	•1°C	• 2°C
	-179 to -145°C	0.08°C	•.75°C	• 1.5°C
	-145 to 1372°C	0.14°C	•.5°C	• 1°C
T	-270 to -261°C	1.5°C	•4°C	• 8°C
	-260 to -251°C	0.38°C	•2°C	• 4°C
	-180 to -136°C	0.08°C	•.75°C	• 1.5°C
	-135 to 400°C	0.06°C	•.5°C	• 1°C
RTD	-220 to 850°C	0.09°C	•.25°C	• .5°C
•10mV			•.025%	• .05%

HIGH SPEED ANALOG INPUTS

- Operating range: -20° C to 70° C
- 4 analog inputs (process variables)
- 2 discrete inputs (timing signals)
- HPC 36003 16-bit microprocessor
- 32 K RAM and 32 K EPROM
- 10 µs input conversion
- 360/1440 data input samples (conversions) per input cycle

AI specs:
- Input ranges (jumper selectable): 1-5 VDC and 4-20mA
- Input sourcing: 24 VDC, jumper selectable, for 4-20 mA loop power
- A/D resolution: 12 bits
- Accuracy: 0.1% at 25° C
  0.2% over -20° C to 70° C

DI specs:
- Input range: 5V
- Off/on threshold: 0.5V/4.5V

Refer to Specification Summary D456 SS-4.

DISCRETE INPUTS

- 5 board types are available
- Isolation: Optical isolation; 1500 V common mode isolation
- Dry contact inputs: Accommodated by jumper selectable internal/external loop power
- Indicator: LED ("on" status); can be disabled
- Counter inputs: Interrupt-driven; maximum 300 Hz on a single input, 800 Hz total pulses on all inputs, can be accommodated by the DI boards; Accumulator or frequency mode selectable in ACCOL software
- PDM input ranges:
  Bristol 5 second (1 to 4 sec);
  Bristol 15 second (3 to 12 sec);
  BIF 15 second (0 to 13.33 sec);
  BIF 60 second (0 to 53.3 sec)
- PDM input variables scaled in ACCOL software

Board Code	Input Quantity	Input Range	Off/On Threshold	Filter Time Constant
K	8	5 Vac/dc	0.5V/4.5V	1 ms*
R	8	12 Vac/dc	1.2V/10.8V	1 ms*
A	8	24 Vac/dc	2.4V/21.6V	1 ms*
B	8	12 Vac/dc	1.2V/10.8V	30 ms
C	8	24 Vac/dc	2.4V/21.6V	30 ms
D	4	120Vac/dc	12V/108V	30 ms

*The 1 ms is appropriate to PDM inputs from Metameters. It must also be used for low speed counter applications.

DISCRETE OUTPUTS

- 3 board types are available
- Relay contact rating:
  2A resistive 50 Vdc or 120 Vac 50/60 Hz
  0.6A inductive 50 Vdc or 120 Vac 50/60 Hz
  0.4A motor 50 Vdc or 120 Vac 50/60 Hz
  0.2A lamp 50 Vdc or 120 Vac 50/60 Hz
- Indicator: LED ("on" status); can be disabled

RTU 3310
SMALL ACCOL REMOTE TERMINAL UNIT

SPECIFICATION SUMMARY D463 SS-1a

- Output modes: Programmable via ACCOL
  On/off latch;
  Momentary;*
  Counter/Pulse;*
  PDM;
  PDO: (Raise/lower pulse duration) with resolutions selectable: 20 ms, 50 ms, 100 ms

*Durations and frequencies depend on ACCOL task interval (0.02 to 5400 s)

Board Code	Output Quantity	Output Type	Source/ Range
E	8	Open Collector	100 mA @ 35 Vdc
F	4	Relay	24V Coil
M	4	Relay	12V Coil

CHECK BEFORE OPERATE (CBO) DISCRETE OUTPUTS

- Provides a reliability check on discrete outputs
- Eight outputs per board
- Three board types available
  - Relays with surge protection
  - Relays with fusing
  - External relays
- CBO Relay Module mounts on an external DIN support rail and connects to the CBO I/O card via a ribbon cable

Refer to specification summary D462SS-2

HIGH SPEED COUNTER INPUTS

- 3 board types are available
- Frequency range: 0 to 10 KHz
- Selectable internal/external loop power for dry contact inputs
- Debounce circuitry: can be enable or disabled
- Set, Reset, Common, and Shield terminals per input
- Isolation: Optical isolation; 1500 V common mode isolation
- Indicator: LED ("on" status); can be disabled

Board Code	Input Quantity	Input Range	Off/On Threshold	Current Draw
G	4	24V	2.4V/21.6V	5 mA
H	4	12V	1.2V/10.8V	5 mA
N	4	5V	0.5V/4.5V	5 mA

HONEYWELL SMARTLINE TRANSMITTER INTERFACE BOARD (HWSTI)

- Provides eight independent, bi-directional communication channels
- Each channel allows Honeywell ST3000 transmitter to communicate with an RTU 3310
- Ground-referenced transmitter power for each input channel
- Plugs into any I/O slot
- Field Termination Assembly (FTA) mounts on an external DIN support rail and connects to the HWSTI via a ribbon cable

Refer to specification summary D462SS-1

ACCESSORIES

DISPLAY/KEYPAD

- Operating range: -20°C to 70°C
- 4 line by 20 character backlit liquid crystal display
- 5 x 5 keyboard matrix
- Field retrofittable
- Parallel interface to I/O bus
- Supported by menu display system in firmware
- Programming: via ACCOL module; consists of specification of signal lists to be accessed by the menu system

Refer to specification summary D456SS-3a

SERIAL PRINTER

- Any serial printer can be connected to an RS232 port
- Programming: via ACCOL logger module and format commands; log format is completely programmable

OPERATOR TERMINAL

- Any serial ASCII terminal can be connected to an RS232 port
- Programming: via ACCOL logger module and format commands; display format and keyboard input are completely programmable

NETWORK INTERFACE BOARD (NIB)

- Required for network termination and surge protection in RS485 networks
- Not used with RS232 or modems

Refer to specification summary D456 SS-2a

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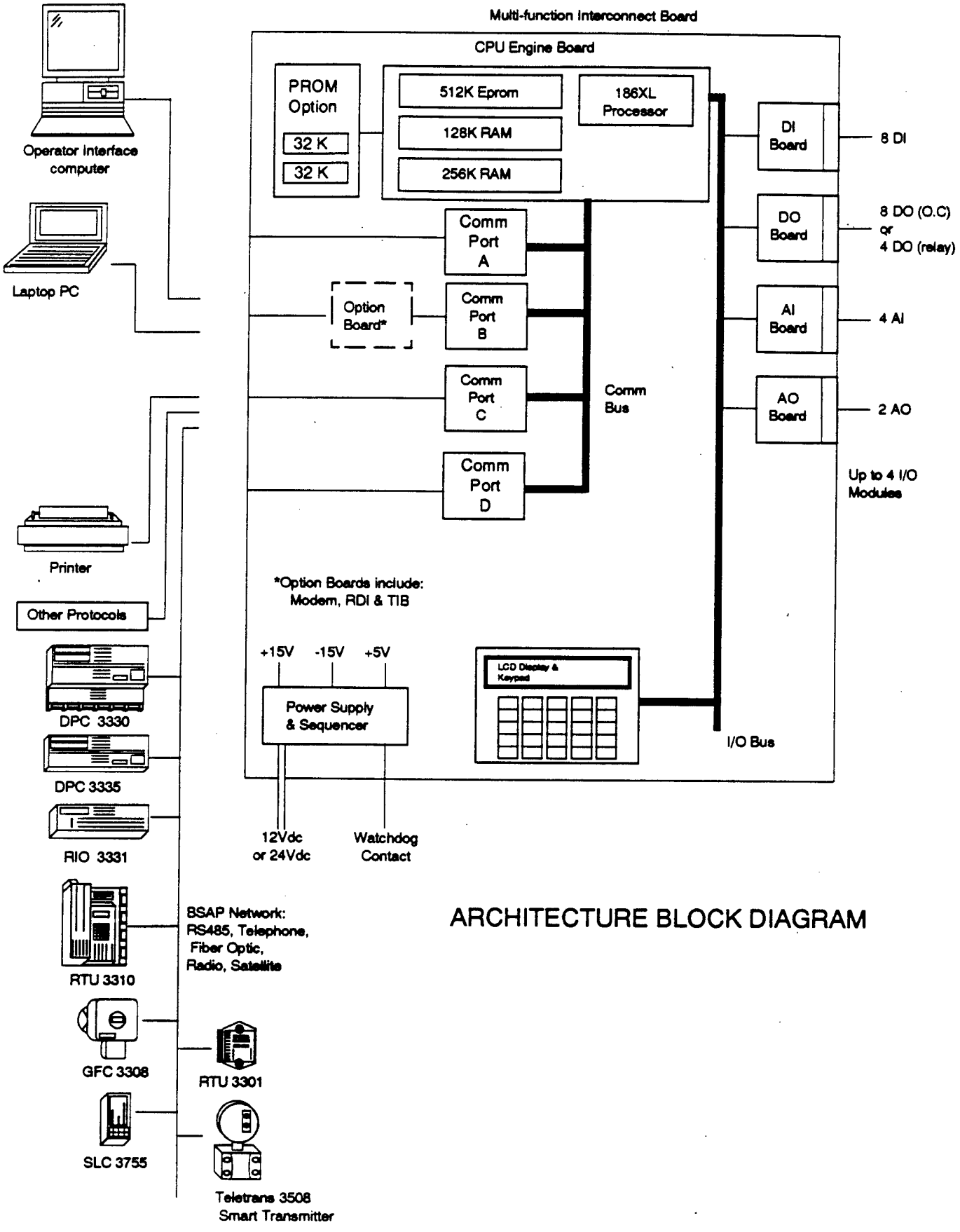
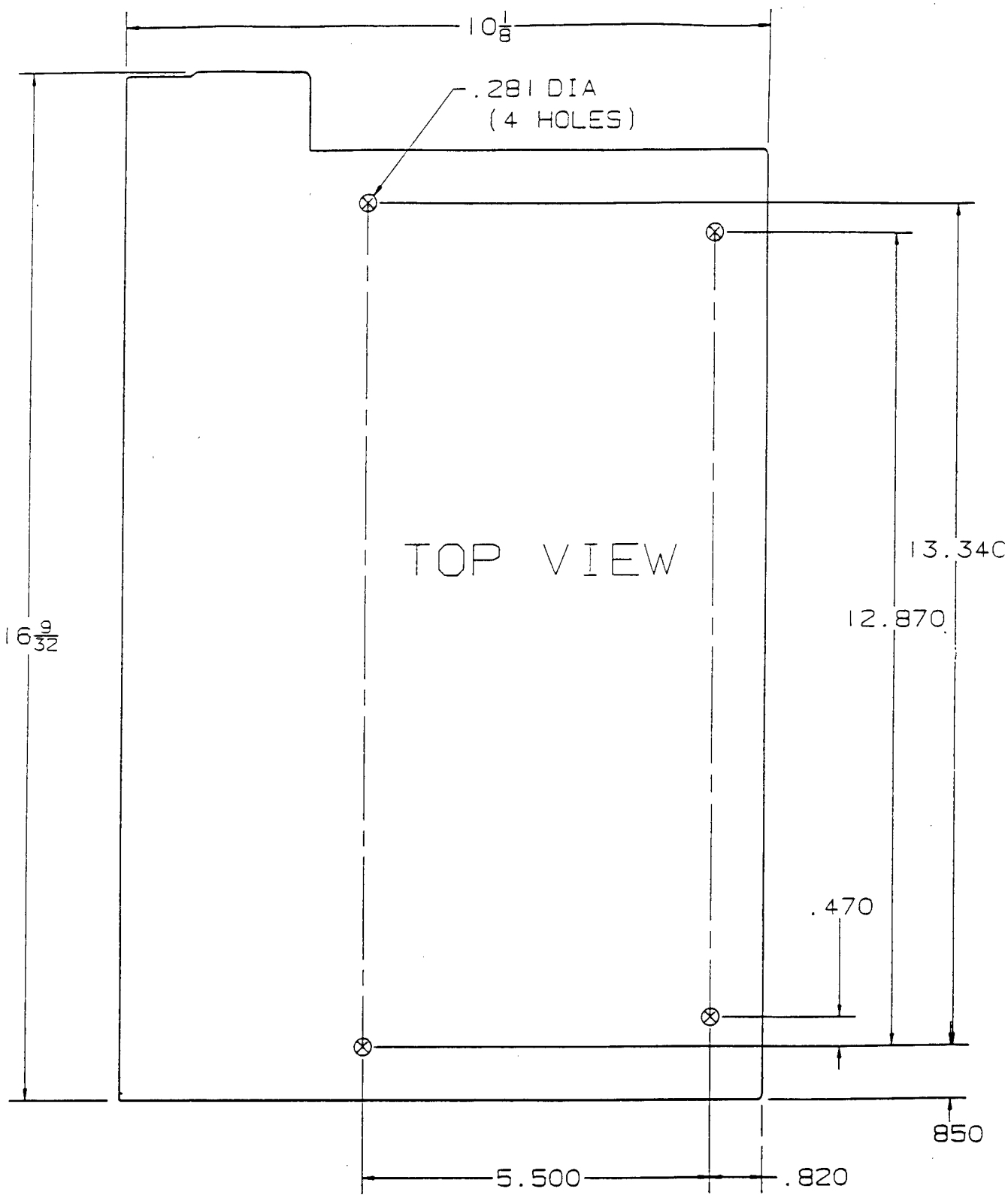
RTU 3310
SMALL ACCOL
REMOTE TERMINAL UNIT

SPECIFICATION SUMMARY

D463 SS-1a



ARCHITECTURE BLOCK DIAGRAM

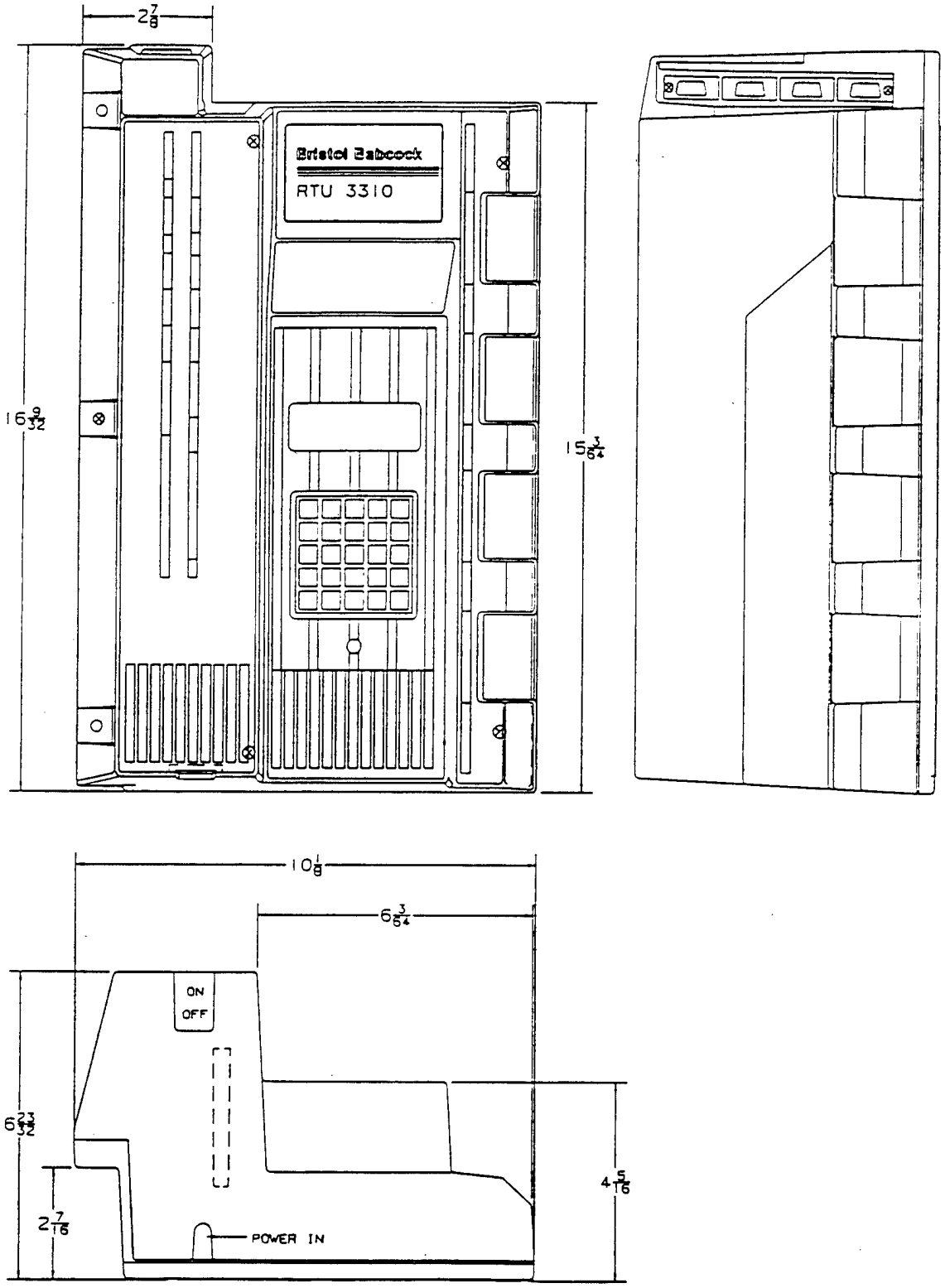


MOUNTING DIMENSIONS
RTU 3310

RTU 3310
SMALL ACCOL
REMOTE TERMINAL UNIT

SPECIFICATION SUMMARY

D463 SS-1a



OUTLINE DIMENSIONS
RTU 3310

RTU 3310
SMALL ACCOL
REMOTE TERMINAL UNIT

SPECIFICATION SUMMARY

D463 SS-1a

	Base						Attch. - A						Attch. - B				Attch. - D		
	A	B	C	- D	E	F	A	B	C	- D	E	F	#1	#2	#3	#4	A	B	C
Model Number: 3310-10A -	__	__	__	- __	__	__	- A __	__	__	- __	__	__	- B __	__	__	__	__	__	__

BASE			CODE
A	**Packaging**	NEMA 1	1
		NEMA 4 FUTURE	2
B	**Power Supply and Communication Options (Notes 1 & 2)**	+12 VDC, 2 Ports: A & B	1
		+24 VDC, 2 Ports: A & B	2
		+12 VDC, 4 Ports: A, B, C, D	3
		+24 VDC, 4 Ports: A, B, C, D	4
C	**Certification**	None	0
		FM	1
D E F	**Not Used**	Enter 0 0 0 for this selection	0 0 0
ATTACHMENT 3310-A			
A	**Not Used**	Enter 0 for this selection	0
B C	**CPU Memory Option**	12 MHz, 128K RAM	0 1
		12 MHz, 384K RAM	0 2
		12 MHz, 64K EPROM, 64K RAM	1 1
		12 MHz, 64K EPROM, 320K RAM	1 2
D	**Communication Port B Options**	RS-485	1
		Private Line Modem	2
		Switched Network Modem	3
		U.K. Modem **Not FM**	4
		Fiber Optic Modem **Not FM**	5
		Radio Delay (RDI) **Not FM**	6
		Transmitter Interface (TIB) **Not FM**	7
E F	**Not Used**	Enter 0 0 for this selection	0 0
ATTACHMENT 3310-B			
#1 #2 #3 #4	**I/O Module Selection**	Specify the I/O module code from the table on the following page, to be installed in each of the four positions in the RTU 3310. Insert a 0 if no module is required in that position.	
ATTACHMENT 3310-D			
A B C	**Display/Keypad**	Built-in Keypad *DO NOT include Attachment 3310-D in the Model Number if no keypad is required.*	2 0 0
ATTACHMENT 3310-Z		**RTU 3310 with:**	
	Conformal Coating	With 0 I/O Boards	Z-100
		With 1 I/O Board	Z-101
	DO Not Include Attachment 3310-Z in the Model Number if Conformal Coating is not required.	With 2 I/O Boards	Z-102
		With 3 I/O Boards	Z-103
		With 4 I/O Boards	Z-104
		With Keypad Display	Z-200

Note 1: +24 VDC to power two wire transmitters or relay contacts not available in 12 V 3310s.
Note 2: A 3310 orderd with two (2) ports can NOT be upgraded to four (4) ports in the field. Ports A & C are RS-232; Port D is RS-485.

RTU 3310
SMALL ACCOL
REMOTE TERMINAL UNIT

SPECIFICATION SUMMARY

D463 SS-1a

Code	I/O Points	Description	
		ANALOG INPUT	
		Input Range	**Common Mode**
1	4	0-10 VDC	No
2	4	1-5 VDC/4-20 mA Note 3	No
3	4	0-10 VDC	Yes
4	4	1-5 VDC/4-20 mA Note 3	Yes
		LOW LEVEL ANALOG INPUT	
5	4	RTD TC J, K, T, R, S, B +/- 10 mV	**600 V C.M. Isolation** Yes
		ANALOG OUTPUT	
		Output Range	
6	2	0-10 VDC	
7	2	1-5 VDC/4-20 mA Note 4	
		DISCRETE INPUT	
		Input Range	**Filter**
A	8	24V AC/DC Note 3	1 mS
R	8	12V AC/DC Note 5	1 mS
B	8	12V AC/DC Note 5	30 mS
C	8	24V AC/DC Note 3	30 mS
D	4	120V AC/DC	30 ms
K	8	5V AC/DC	1mS
		DISCRETE OUTPUT	
		Output Type	
E	8	Open Collector	
F	4	Relay, +24V Coil Note 4	
M	4	Relay, +12V Coil Note 6	
		HIGH SPEED COUNTER	
G	4	+24 V Input Range Note 3	
H	4	+12 V Input Range Note 5	
N	4	+5 V Input Range	
P		**High Speed Analog Input** 4 AI (1-5 VDC/4-20 mA) 2DI (5V AC/DC)	
S	8	**Honeywell Smart Transmitter Interface** Replace 10 ft. cable with 30 ft. cable (PN: 391274-02-3)	
		CHECK BEFORE OPERATE	**Not FM Approved**
T	8	C.B.O. with Surge Protection	
U	8	C.B.O. with Fusing	
V	8	C.B.O. with External Relays	

Note 3: 24 volt range I/O cards used with 12 volt internal power require an external 24 volt supply if power for contacts or transmitters is needed.

Note 4: Cannot be used with 12 V internal power.

Note 5: 12 volt range I/O cards used with 24 volt internal power require an external 12 volt supply if power for contacts or transmitters is needed.

Note 6: Cannot be used with 24 V internal power.

SPECIFICATION SUMMARY

B225-60a

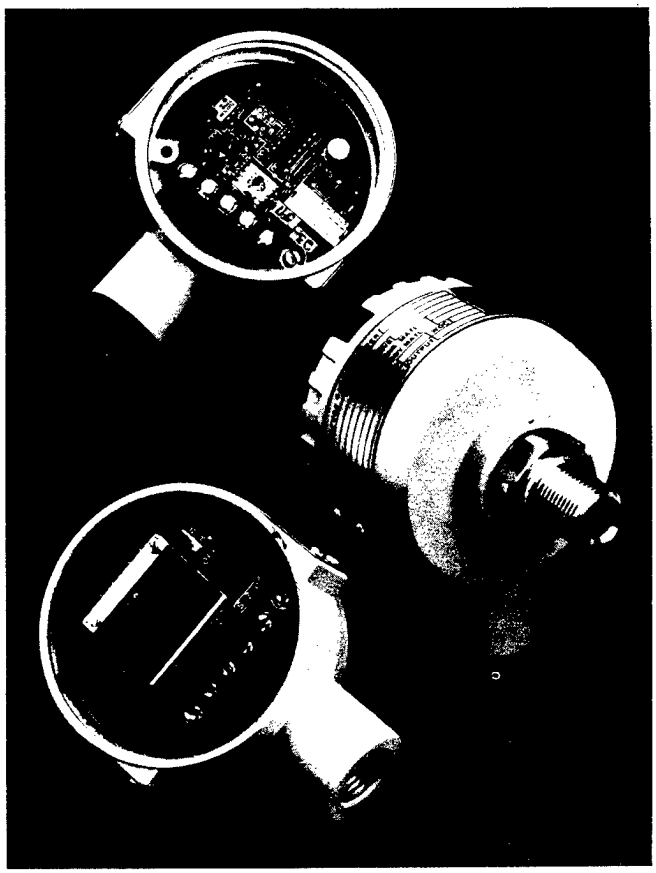
SIGNATURE®2508-15B
PRESSURE TRANSMITTER

FEATURES

- o Low cost of ownership
- o ±0.15% accuracy
- o Direct process mounting
- o 2-year warranty
- o Explosion proof electronic housing
- o Local indicator option, linear or in engineering units

The 2508-15B is a compact, low cost transmitter designed to accurately measure gauge pressure and transmit a proportional 4-20 mA signal. The transmitter is installed on, and supported by, the process piping. This eliminates the need for optional mounting hardware for most applications. The 2508-15B has an initial cost that makes repair by total replacement a truly practical concept. Spare parts inventory and maintenance training is thus eliminated.

The 15B is an adjustable range transmitter that is calibrated at the factory to a specific measurement range. Input ranges covering 100 inches H_2O through 5000 psig are available. Zero and span adjustments are available inside the electronic housing for making minor "touch up" adjustments in the field. These zero and span adjustments are completely non-interacting. The 15B has an electronics function board that permits a 6:1 span adjustment capability, zero elevation and suppression, and adjustable damping. This modular design concept makes the 15B a truly low cost transmitter for just about all applications.



OPERATION

The sensor module provides a 1/2 inch NPT bottom entry process connection. This connection exposes one side of the process diaphragm to line pressure. The 15B contains a micromachined transduction element, fabricated using integrated circuit technology, to sense input pressure. This sensing technology combines the mechanical aspects of silicon, which is literally as strong as steel and hysteresis free, with the inherent semiconductor and electronic properties of an integrated circuit. The sensor consists of an internal silicon diaphragm into which piezoresistive strain gauge resistors are diffused, then interconnected to form a pressure sensitive Wheatstone Bridge. The outer process diaphragm is hydraulically connected to the silicon diaphragm using a suitable fill fluid. When the sensor is energized, by applying pressure to the outer diaphragm, the silicon diaphragm deflects, resulting in an electrical output change proportional to the input pressure. Because of the single crystal nature of the silicon diaphragm, linearity is excellent and pressure hysteresis is essentially unmeasurable.

Bristol Babcock

SIGNATURE® 2508-15B
PRESSURE TRANSMITTER

SPECIFICATION SUMMARY

B225-60a

FUNCTIONAL SPECIFICATIONS

- **Input ranges**
  0-100 in. H2O to 0-5000 psig

- **Span adjustment**
  6:1 span adjustment
  Internal fine adjustment

- **Zero adjustment**
  Up to 600% LRL for elevation/ Up to 500% LRL for suppression
  Internal fine adjustment

- **Output**
  4-20 mAdc (2 ma minimum, 35 ma maximum)
  Two wire electronics

- **Temperature limit**
  Wet end:
  -40° to 104° C (-40° to 220° F) DC 200 Fill
  -17.8° to 104° C (0° to 220° F) Fluorolube Fill
  Note: When process media temperature exceeds 185° F, the electronics ambient temperature must be reduced to insure the electronics temperature never exceeds 185° F.

  Electronics:
  -32° to 85° C (-25° F to 185° F)
  Local Indicator (Digital) = -30° C to +80° C

  Storage:
  -40° to 100° C (-40° to 212° F)
  Local Indicator (Digital) = -40° C to +80° C
  (with electronic housing covers i nstalled)

- **Damping**
  Time constant: (time for a 63% change in output with a 100% input change)

  Damping ON: 0.15 sec ± 25% time constant
  Damping OFF: Less than 10ms

  Time to steady output after application of 24 volts supply with constant pressure: 10 msec maximum

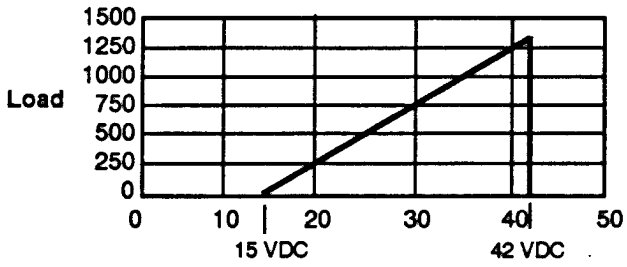
  NOTE: Damping is optional. (via moveable jumper)

- **Overpressure limits**
  3 x URL

- **Power supply**
  24 volts dc normal

- **Humidity limits (covers in place)**
  15-95% RH to 60° C max.
  15-50% RH to 85° C max.
  Local Indicator (Digital) = 15-95% RH to 60° C max.
  15-50% RH to 80° C max.

Operating Load vs. Supply Voltage



Supply Voltage Volts dc

Note: Minimum of 250 OHMs resistance must be series with Loop for power supply voltages between 36 & 42 VDC.

PERFORMANCE SPECIFICATIONS

- **Accuracy**
  ±0.15% of calibrated span (includes linearity (.1% typical), repeatability (.05% typical), and hysteresis (.05% typical))

- **Stability**
  0.25% URL per six months at reference conditions (75° F)
  Zero and span

- **Overpressure effect**
  0.25% URL/maximum operating pressure

- **Mounting position effect**
  ±2 inches H_2O maximum, which can be calibrated out

- **Power supply effect**
  ±0.005% URL/Vdc

- **EMI effect**
  ±1% URL @ 10 V/M 20 to 500 MHz

- **Surge protection**
  1000 watts for 1 ms

- **Ambient temperature effect (total includes zero and span)**
  ±0.015% of URL per °F from -25 to 75°F
  ±0.01% of URL per °F from 75 to 185°F
  ±0.02% of URL per °F 100 IN WTR only

- **Dead band**
  Less than .05% of span

SIGNATURE® 2508-15B
PRESSURE TRANSMITTER

SPECIFICATION SUMMARY B225-60a

PHYSICAL SPECIFICATIONS

- **Diaphragm material/body material**
  316 stainless steel standard
  Hastelloy C
- **Process connection**
  1/2 inch NPT male
  Bottom entry
- **Electrical connection**
  1/2 inch NPT conduit connection
- **Weight**
  1 1/2 pounds
- **Fill fluids**
  DC 200 silicone oil standard
  Fluorolube
- **Electronics enclosure**
  Low copper aluminum with epoxy paint
  1/2 inch female conduit connection
  NEMA 4 weatherproof
  Designed to meet FM explosion proof certification for hazardous areas
  Local output meter option
- **Certification**
  Factory Mutual (FM) approved
  Class I, Division 1, Groups B, C, and D (ExplosionProof)
  Class I, Division 2, Groups A, B, C, and D (Non Incendive)
  Class II, Division 1, Groups E, F, and G (Dust-Ignition Proof)
  Class III, Division 1

MODEL NUMBER SPECIFICATION

2508-15B-ABC-DEF-GHJ-KMN

AB. Input range

Min. Span		Max. Span	Range
0-17	to	0-100 in. H2O	13
0-50	to	0-300 in. H2O	14
0-67	to	0-400 in. H2O	15
0-4.2	to	0-25 psig	20
0-8.3	to	0-50 psig	21
0-17	to	0-100 psig	22
0-50	to	0-300 psig	23
0-83	to	0-500 psig	24
0-167	to	0-1000 psig	25
0-500	to	0-3000 psig	26
0-833	to	0-5000 psig	27

C. Unused character

N/A 0

D. Material, wetted parts

316 stainless steel 2
Hastelloy C 3

E. Filling media

DC 200 1
Fluorolube 2

F. Function board

Adjustable range 2

G. Local indication

None 0
Integral Digital Meter 1

H. Mounting bracket

None 0
Bracket 1

JK. Certification

None 00
FM - Explosion proof/non-incendive 01

MN. 00

Options and Accessories:
Block and Bleed Valves:
Carbon Steel: 390702-02-1
Stainless Steel: 390702-01-3
Attachment A300 - 2 Position Signal Damping . . .

Bristol Babcock

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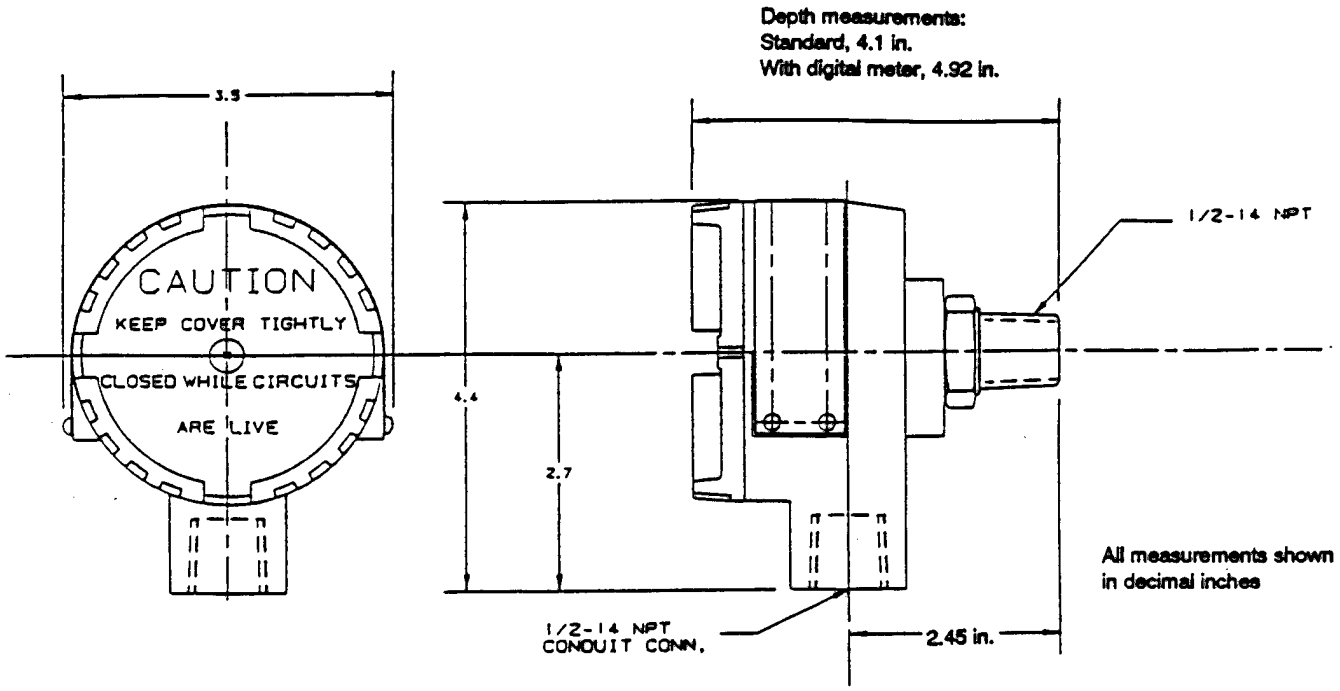
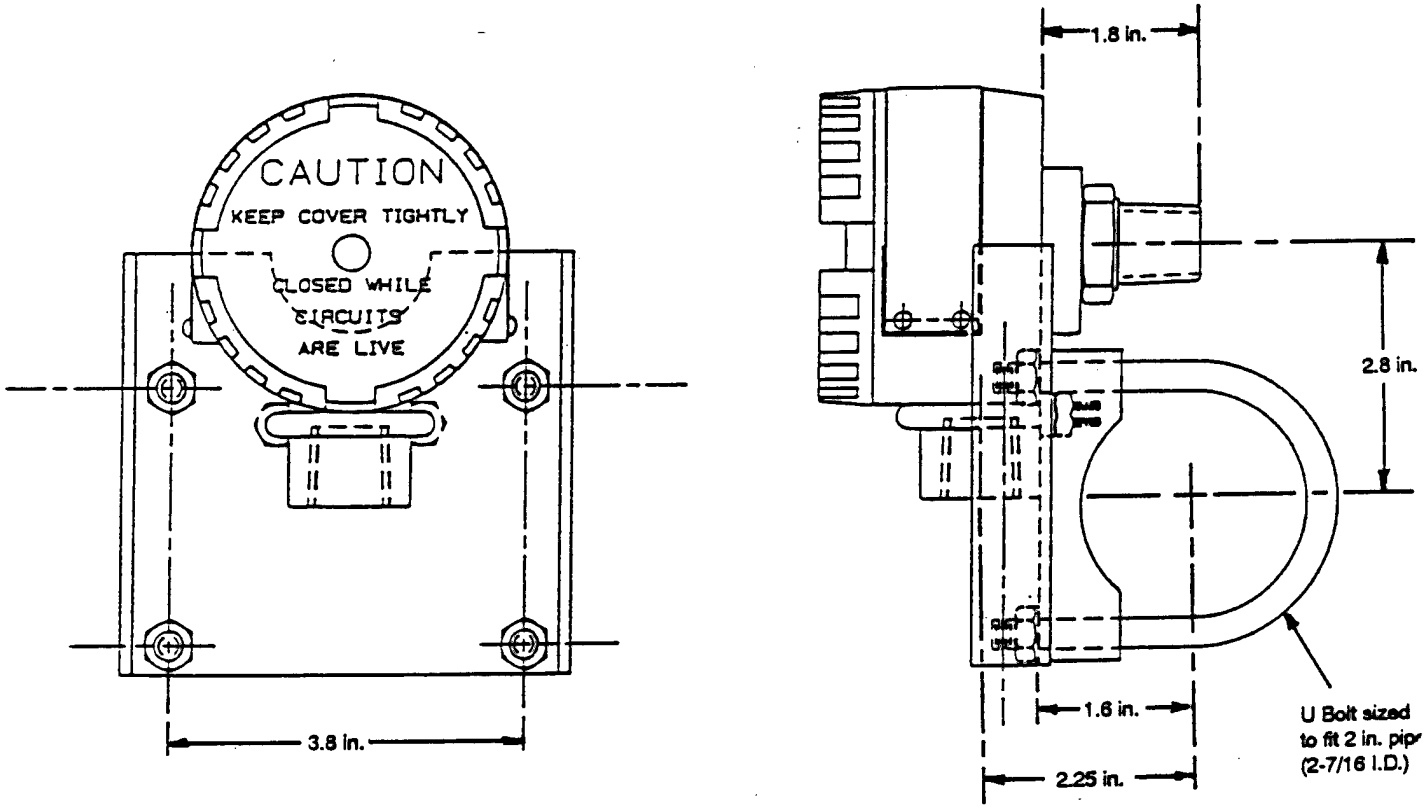


Overall Dimensions - Model 2508-15B



Pipe Mounting Bracket

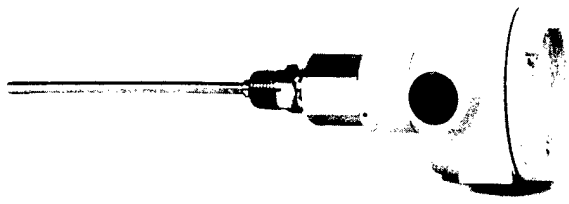
SPECIFICATION SUMMARY

B225-65a

2508-41B
SIGNATURE RTD TEMPERATURE TRANSMITTER

The Bristol Babcock 2508-41B transmitter is a high performance, user scaled, 4 - 20 mA temperature transmitter which can be used with standard RTDs to provide a (linear to temperature) current loop output. A large range of adjustability is accomplished by using a four position soldered jumper (located on the circuit board), which allows the user to configure the system over a wide dynamic input range for a given RTD, eliminating the need for transmitters scaled for one particular range only. In addition, zero and span pots are available (also on the circuit board) for making fine trim adjustments in the field.

The temperature transmitter can be ordered with or without RTD sensors. The sensor mounting adapter is designed for probes with 1/2" - 14 NPT threads. The electronics are contained within a housing designed for explosion proof. Electrical connections are via a 1/2" NPT port.



FUNCTIONAL SPECIFICATIONS

INPUT

- **RTD Type:** 100 ohm pt., Alpha 385
- **Range Limits:** -50°C to 850°C (-58°F to 1562°F)
- **Span Adjustment:** 50°C to 800°C (90°F to 1440°F)
- **Zero Adjustment:** -50°C to +50°C (-58°F to 122°F)
- **Power Supply:** 10 Vdc to 36 Vdc, polarity protected
- **Sensor Lead Wire Effect:** 0.01°C/ohm
- **Maximum Lead Resistance:** 500 ohms
- **Power Supply Effect:** ± 0.002% of span/Vdc

OUTPUT

- **Range:** 4 to 20 mA nominal
  Open Circuit Detection: Upscale, equal to or greater than 23 mA, limited to 40 mA
- **Current Loop Impedence:** $R(K\ ohms) = \frac{(Vs - 10)}{20}$
- **Output Load Sensitivity:** 0.015% of FSO/500 ohms

PERFORMANCE

- **Accuracy:** ±.15% of calibrated span, linear with temperature, for spans equal to or less than 500°C
  ±.3% of calibrated span, linear with temperature, for spans greater than 500°C
- **Temperature Effects:** ±0.02% of URL/°C, combined effects of zero + span
- **Temperature Limits:** Operating -10 to 70°C (14 to 158°F)
  Storage -20 to 100°C (-4 to 212°F)
- **RFI Immunity:** Meets SAMA PMC 33.1 - 1978 over 20-500 MHz
- **Relative Humidity Limit:** 90% non-condensing at 70°C
- **Hazardous Locations:** Certification pending
  Explosion Proof Class I, Div 1, Groups B, C, D
  Non Incendive Class I, Div 2, Groups A, B, C, D
  Dust Ignition Proof Class II, Div 1, Groups E, F, G
  Suitable for Class III (ignitable fiber), Div 1, indoor and outdoor (NEMA 4X)

Bristol Babcock

2508-41B
SIGNATURE RTD TEMPERATURE TRANSMITTER

SPECIFICATION SUMMARY

B225-65a

MODEL SPECIFICATIONS

2508-41B-ABC-DEF

A. INPUT
- 100 Ohm PT 1
- DIN 43760
- Alpha 385

B. MOUNTING BRACKET
- None 0
- Universal 2" pipe 1

C. CERTIFICATION
- None 0
- (Pending)

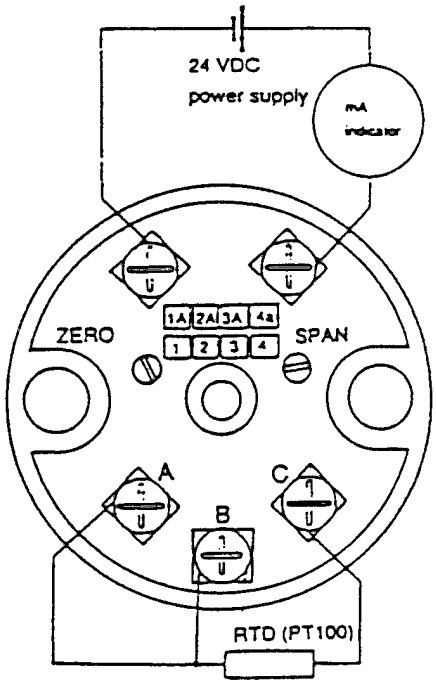
D. MOUNTING OF ACCESSORIES (Note 1)
- None 0
- W/GP Sensor 1
- W/GP Sensor, coupling extension 2
- W/GP Sensor, union extension 3
- W/Spring loaded sensor & well 7
- W/Spring loaded sensor, coupled extension & thermowell 8

E.F. 00

Note 1: For accessories, refer to spec. summary sheet B225-90a.

Desired Span in °C
RTD DIN 43760

JUMPER	Pt 100 (α 0.00385)
1 - 1A	50 - 100
2 - 2A	100 - 200
3 - 3A	200 - 400
4 - 4A	400 - 800



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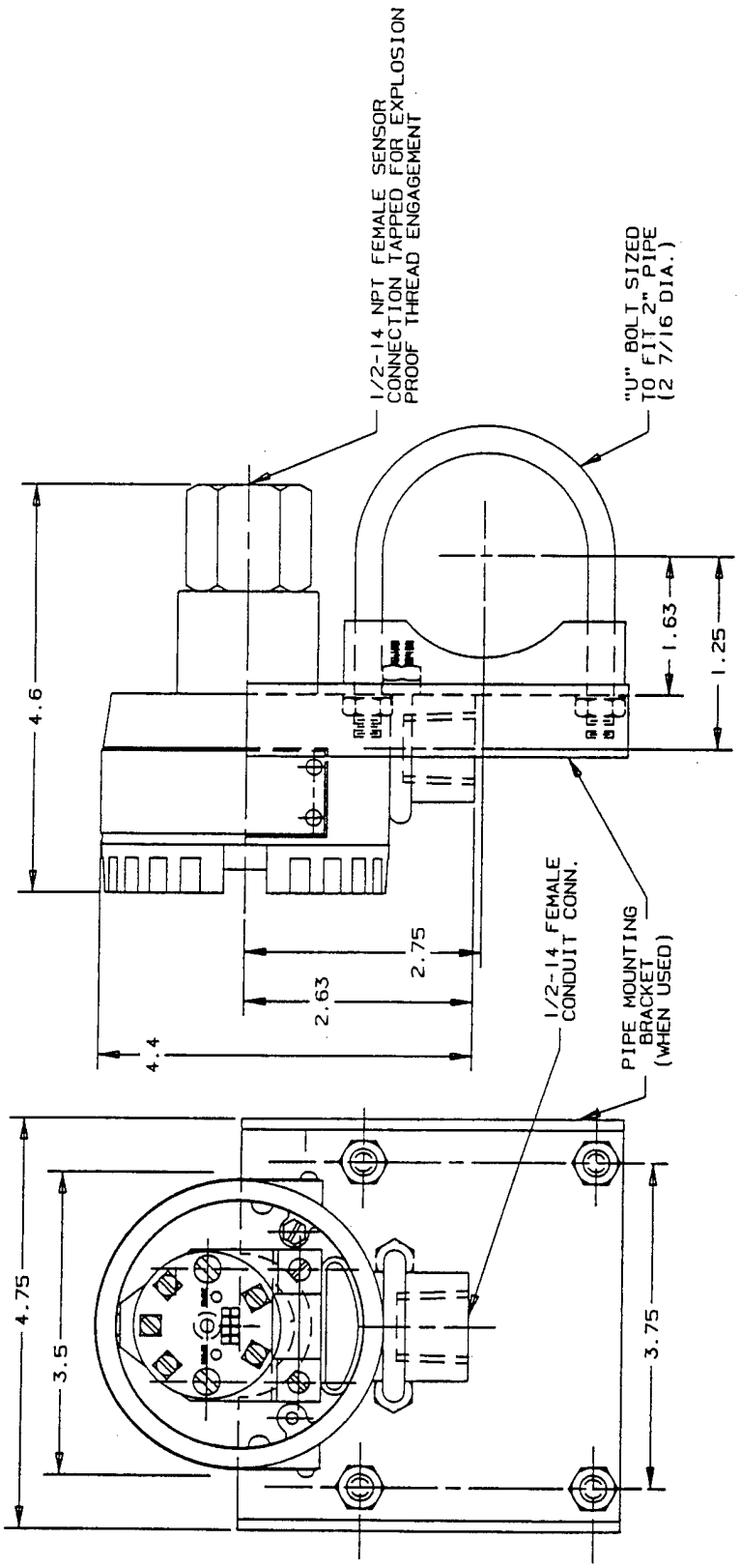


Overall Dimensions - 2508-41B

BRISTOL BABCOCK instruments/systems

ACCESSORIES FOR SIGNATURE® TEMPERATURE TRANSMITTER

- RTD Sensors
- Thermocouple Sensors
- Thermowells
- Extension Assemblies
- Connection Heads

See back of this page

For use in conjunction with Signature Temperature Transmitters, Bristol Babcock offers a selection of RTD and Thermocouple Sensors, Thermowells, Extension assemblies and Connection Heads to cover various industrial applications.

The items listed can be ordered with transmitters or separately and in most cases be provided mounted to the transmitter if applicable. (See Specification Summaries B225–40 and B225–45 for details.)

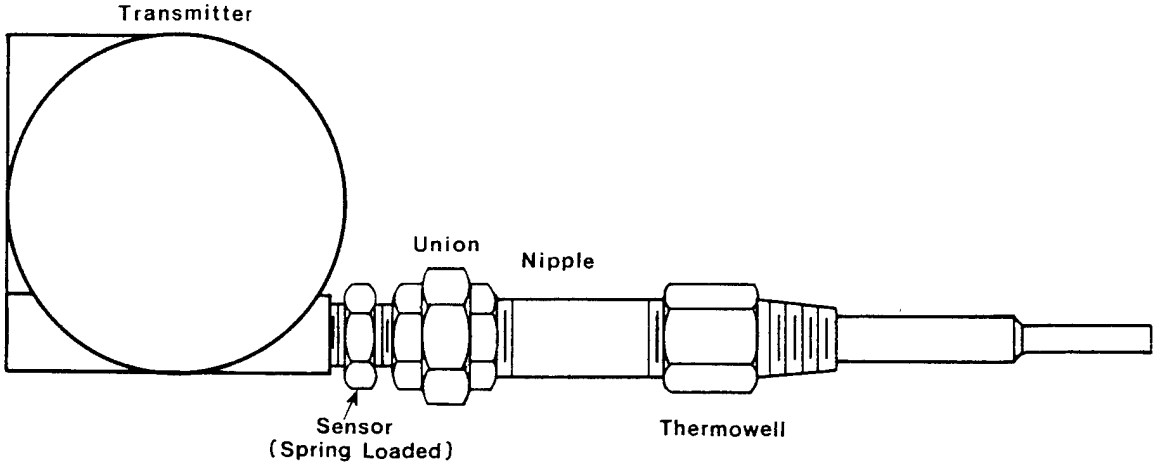
Sensors are available in general purpose (recommended for direct process mounting) and spring loaded (recommended for use with thermowells). All RTD sensors are rated at 0.1% conformance to the DIN43760 temperature vs. resistance curve (0.00385 ohms/ohms/degree C) Thermocouple sensors of types JKTE and R are rated at 0.1% conformance to ANSI 96.1-1982 standards.

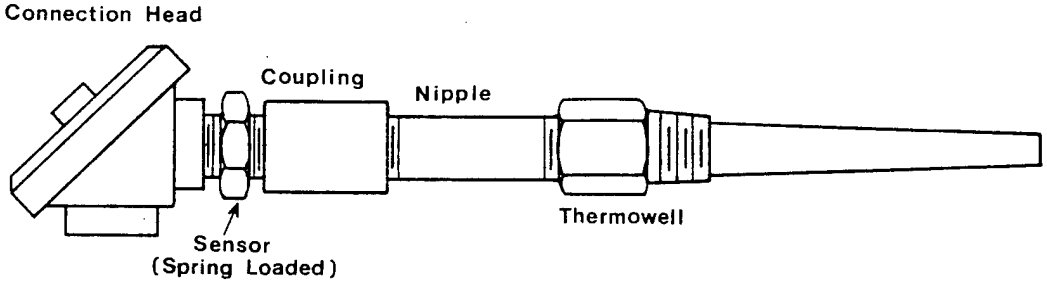
Thermowells of stepped and tapered design are available with threaded, socket weld, and flanged process connections. These configurations are also available in various lengths and process connection sizes.

For use where piping insulation and/or high process temperatures are encountered, extension assemblies of the coupling/nipple and union/nipple types are provided. Lengths from 2 to 9 inches are normally available in 304 SS material.

Connection heads are also available for remote mounting of sensors from the transmitter as applications warrant. Brass terminals are provided for RTD or thermocouple leads to reduce error.

TYPICAL ARRANGEMENTS



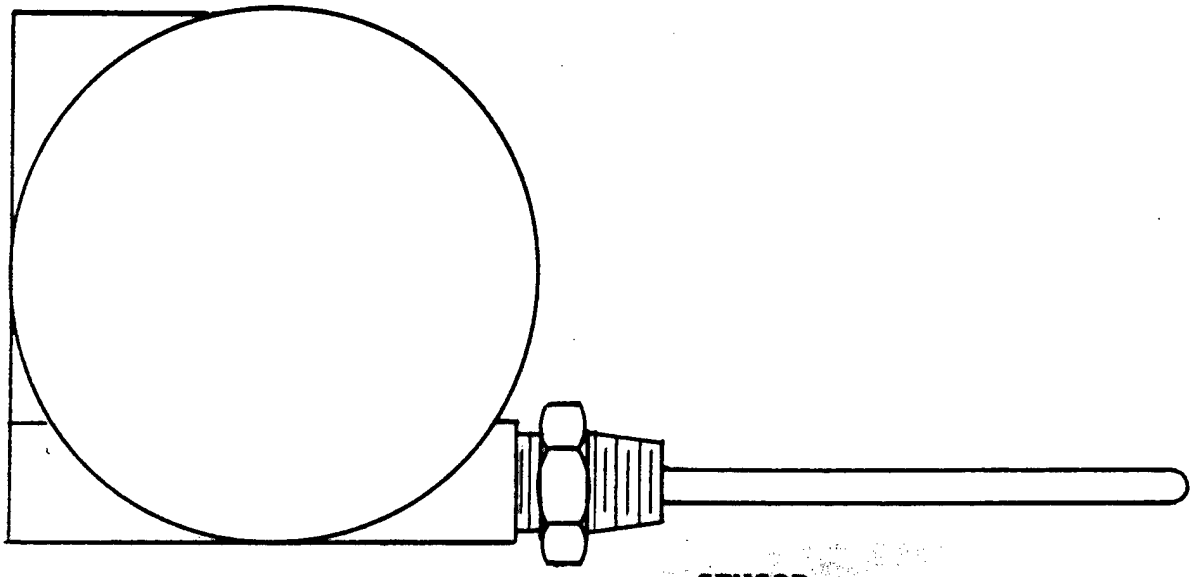


SPECIFICATION SUMMARY SHEET B225-90 a

ACCESSORIES FOR SIGNATURE® TEMPERATURE TRANSMITTER

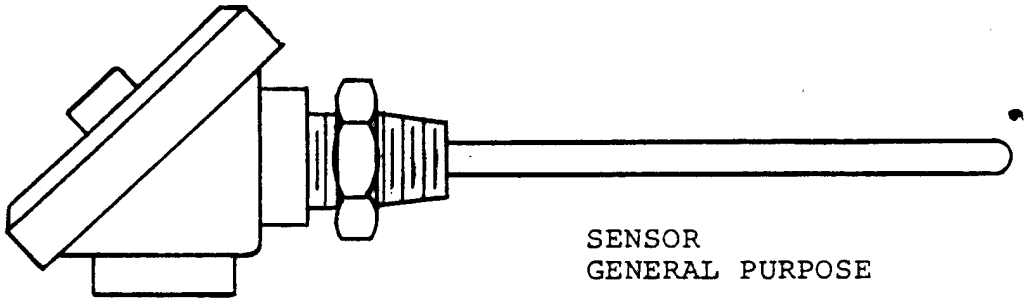
SPECIFICATION SUMMARY SHEET B225-90 a

TRANSMITTER



SENSOR
GENERAL PURPOSE

CONNECTION HEAD



SENSOR
GENERAL PURPOSE

Bristol Babcock Inc.
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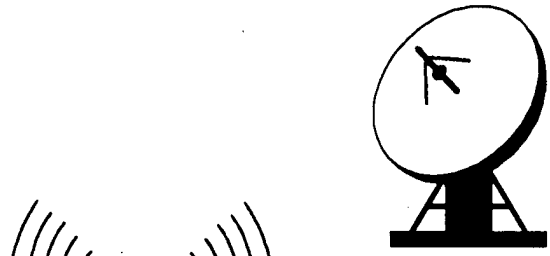
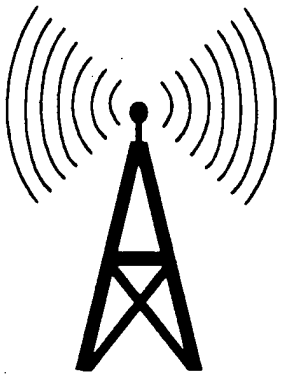
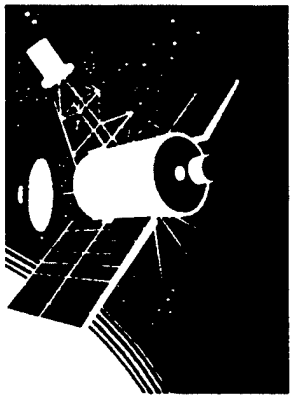
SPECIFICATION SUMMARY

D454SS-6a



NETWORK 3000
BSAP
Bristol Standard Asynchronous/ Synchronous Protocol





FEATURES

- o Compatible with SCADA and LAN networks
- o ISO 1745/2111/2629 compliant
- o Tree topology network
- o Up to 6 network levels
- o Up to 127 nodes from each node at a level
- o Polled network
- o Local and global addressing
- o Peer-to-peer and RDB modes
- o Report by exception
- o Alarm handling
- o Network time synchronization
- o 16 bit CRC-CCITT error checking
- o Communication statistics and diagnostics

Bristol Standard Asynchronous/Synchronous Protocol (BSAP) provides a complete communication framework for all Bristol Babcock Network 3000 products. It is a poll oriented communication system for horizontal LAN as well as vertical, multilayer networks. Consequently, BSAP is equally well suited to both synchronous high speed local networks and asynchronous low speed wide area networks. BSAP is able to offer extremely high message security, required for phone line and radio networks, through the use of 16 bit CRC-CCITT error checking, handshaking, and extensive communication statistics reporting. The polling scheme employed by BSAP ensures that each node in the network has an equal opportunity to be polled and to respond. In addition, no node can dominate the network communication. BSAP supports both local and global addressing to all Network 3000 nodes in a network.

Network Topology

At the top of the network is the network master or host, typically a personal computer or mini computer performing graphical user interface functions. The network master normally connects to one (or sometimes more) Bristol process controllers commonly referred to as a data concentrator or communications front end. It in turn becomes a master node to up to 127 slave nodes. Each of those can then be a master to another level of slave nodes. This hierarchy can extend up to six levels deep. Each intermediate node has both master and slave capability through separate communication ports. This architecture lends itself very well to the typical geographical distribution of controllers in most SCADA system applications. It also allows multiple asynchronous communications to occur throughout the network since each network branch can communicate simultaneously.

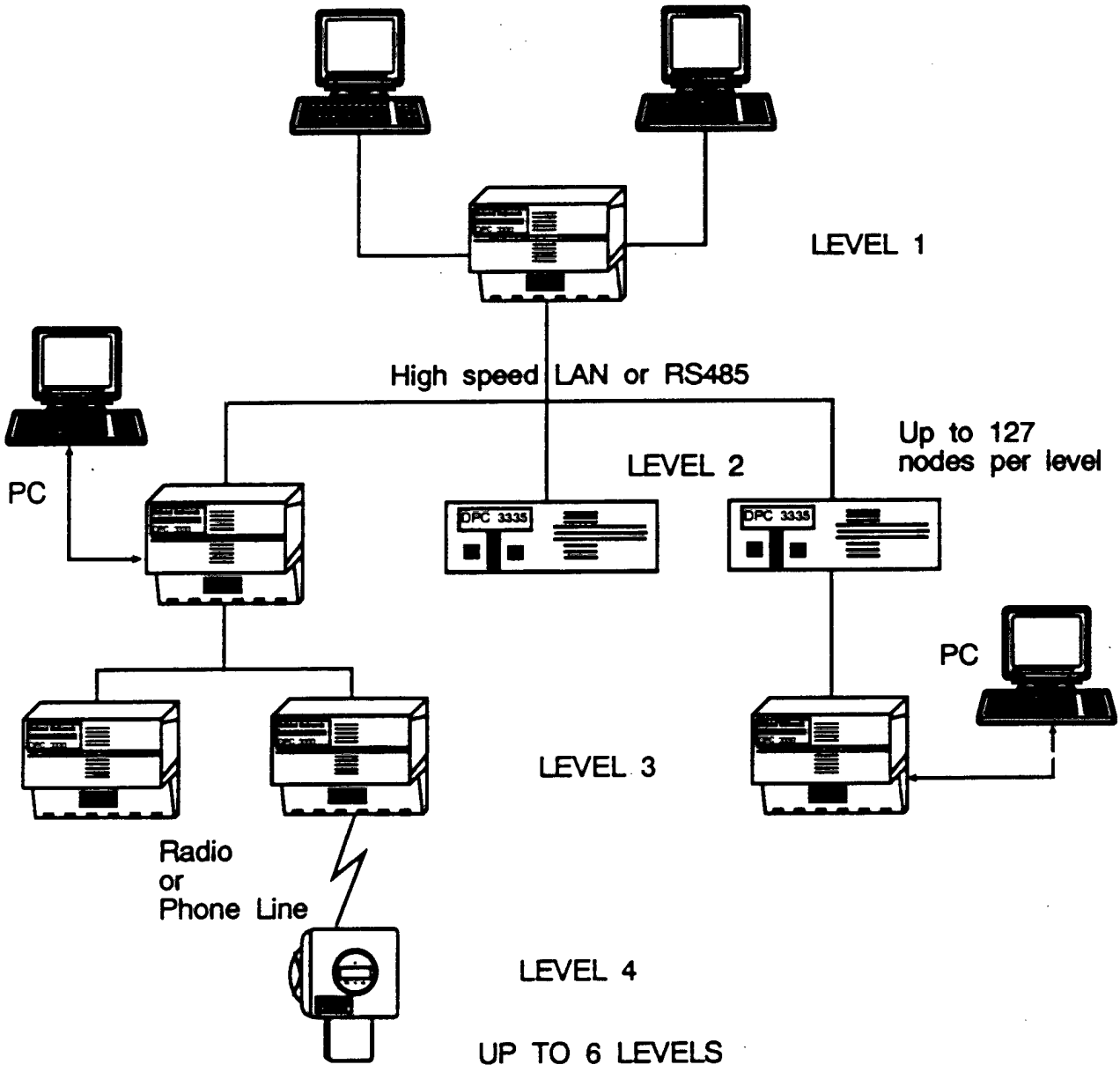
Local and Global addressing

The computer at the top of the network has the ability to communicate locally to its attached node or through it to any other node in the network. In addition, a computer attached to a lower level node, through a Pseudo-slave port, can have access to any data, except alarms, in any other node in the network. This computer will have access to alarms from its attached node and any nodes below it. Each Network 3000

NETWORK 3000
BSAP
BRISTOL STANDARD ASYNCHRONOUS PROTOCOL

SPECIFICATION SUMMARY D454SS-6a

NETWORK EXAMPLE



process controller can actually support up to three personal computers. One on the slave port, one on a pseude-slave with alarms, and one on a pseudo- slave without alarms.

In some systems it is convenient to have all data from all nodes collected by the top level node, commonly referred to as a data concentrator. The host computer will then communicate locally to that node only, since that is where all network data resides. Other systems may be configured to communicate globally through the data concentrator directly to the slave nodes. This communication mode is called Remote Data Base access (RDB), described later. Many systems will be configured to utilize both techniques, thus maximizing communication efficiency as well as ease of implementation.

Since BASP provides multi-message capability which is essentially transparent to the user, it is possible to connect a computer to any node in the network and communicate with the attached node or any other node in the network. This capability includes data collection, command changes, and reconfiguration and downloading of ACCOL control strategies. In fact, all of these communications can be occurring simultaneously, without interference, within the network.

Peer to Peer Communication

Peer to peer communication is a mechanism for transferring data blocks, such as signal lists and data arrays, between any two adjacent nodes in a network. Peer to peer uses ACCOL Master/Slave modules which should not be confused with BSAP master/slave communication. A BSAP slave may have an ACCOL Master module and a BSAP master may have an ACCOL Slave module. Master modules execute periodically at the rate of the ACCOL task in which they are included. Once a Master module executes the message request is passed off to BSAP for communication. Slave modules execute asynchronously with respect to ACCOL tasks. When a command is received from a Master module, it is executed immediately.

Remote Database Access

Remote Data Base (RDB) communication is used for reading and writing of individual ACCOL signals or signal statuses. Individual signals may be requested by name or by physical address within the node. RDB can also be used to read or write data arrays and data array elements. RDB requests for data and commands are initiated by the host computer. There are no ACCOL modules required to pass these messages throughout the network. In many cases network communication is structured to use peer to peer for data collection and RDB for commands.

RDB is implemented such that the host computer will read a signal variable by name the first time that ACCOL signal is requested. The response to the request will include the memory address in the node which contains the value of the signal. All further communications to the node requesting that signal will be by memory address rather than signal name. Reading by address requires less communication overhead than reading by signal name, thus reducing communication time.

Report By Exception

Report By Exception (RBE) provides an effective technique to maximize communication efficiency. Since RBE reduces network communication traffic it is particularly useful in low speed SCADA systems communicating over modem and radio networks. When RBE is enabled, a node will respond to a poll by transmitting only the values that have changed since the last poll and any alarms. RBE communication is selectable on an individual signal basis.

It is possible and often advantageous to mix communication modes within the same system and even in the same node. For example, historical data may be passed up the network to the data concentrator using peer to peer, commands from the host computer will be sent down the network to the destination node by RDB, and display data may be gathered on an RBE basis.

Alarm Handling

ACCOL alarm signals produce buffered, time stamped alarm messages which are automatically transferred up the network to the host computer. When a node is polled by its master it will, if requested, respond with an alarm message, with time/date stamp, that have been posted since the last poll. Alarm reports have a higher communication priority than all other messages cued to go up the network. Each node contains space to buffer alarm messages from nodes below it. If the buffer becomes full due to a communication failure at a higher level the node will not permit additional alarm message transfer from its slave nodes. The slave nodes will then begin buffering alarm messages. This throttling effect is used to prevent a node from becoming overwhelmed with alarm messages at any one time. Individual alarms may be acknowledged by an operator at the host computer. This activity will send the acknowledged status down the network to the node initiating the alarm. BSAP also supports alarm report initialization. This feature, initiated by the host computer, will instruct all nodes in the network to report all current alarms that are unacknowledged.

Time Synchronization

The Time Syncronization/Node Routing Table (TS/NRT) combined message enables each node in the network to know the topology of the network including the nodes unique global address and current time and date. The TS/NRT message emanates from the host computer to the top level node which in turn broadcasts it to its slave nodes which send it to their

slave nodes. A network may have only one master capable of issuing a TS/NRT ensuring the entire network is in sync.

Polling Philosophy

Each node in the network, except the lowest level nodes, is both a master to the nodes below it and a slave to the master node above it. A master node sends data request messages to the slave nodes then periodically polls its slave nodes for alarms and response data messages. The polling philosophy used maintains four types of polls to maximize throughput by minimizing extraneous communication. The four poll types are:

1. Main poll
2. Reactivation poll
3. Preferred poll
4. Dead node poll

The main poll loop interrogates each slave at the start of each poll period to determine if it is alive and if it has any response messages. A live slave which responds with a data message becomes a candidate for a preferred poll. If the slave responds but has no messages it will be ignored until the next main polling cycle. If a slave node fails to respond to three consecutive polls it is assumed dead and will be subject to reactivation polling.

The reactivation poll is attempted only once per polling cycle to determine if a known dead slave has come alive. One dead slave is polled each polling cycle on a rotating basis to ensure that every dead slave node gets an equal chance to respond. If a dead node responds its status is changed to live and becomes a member of the main poll loop.

The preferred poll loop interrogates, on a round robin basis, all of the slaves that responded to the main poll or reactivation poll with data messages. Responding slave nodes will continue to be polled in sequential address order until the end of the poll period or until there are no more response messages.
If there is time left after the preferred poll, the dead poll loop is used to give any remaining dead nodes an opportunity to advise the master that they are alive.

Poll Periods

Each communication line within a network has a user defined poll period configurable from .1 sec. The poll period is the minimum time between each main polling cycle of the slave nodes from the master node. It is a function of the number of slave nodes, baud rate, physical link (i.e. leased line, dial line, radio, RS 485, coax, or fiber), message type, and the number of analog and discrete values to be transmitted. The following table shows the relative rates assuming a master communicating 20 analog signals and 40 discrete values from each of ten slave nodes. The total time is the time required to communicate all values from all 10 slaves and includes 25% spare time for alarms.

Baud Rate	Message	Recommended Poll period	Required # of polls	Total Time
1200 baud leased line	RDB	24.5 sec	2	49 sec
1200 baud leased line	peer to peer	18.8 sec	1	18.8 sec
1200 baud radio	RDB	39.8 sec	2	59.6 sec
1200 baud radio	peer to peer	34.1 sec	1	34.1 sec
9600 baud	RDB	3.1 sec	2	6.2 sec
9600 baud	peer to peer	2.4 sec	1	2.4 sec
1 Mbaud	RDB	.2 sec	2	.4 sec
1 Mbaud	peer to peer	.2 sec	1	.2 sec

Message Security

BSAP employes 16 bit CRC-CCITT error checking to ensure message security. This 16 bit CRC technique catches all single and double errors, all errors with an odd number of bits, all burst errors of 16 or less, 99.997% of 17-bit error bursts, and 99.998% of 18-bit and longer bursts. These statistics are based upon pure bit data. Since BSAP is a message structure with handshaking and additional diagnostics, the overall security is even greater than stated.

All Network 3000 nodes retain on-line statistics reflecting the integrity of all communication transactions. An independent set of statistics is maintained for each communication line (serial port) at each node.

The embedded handshaking of message communication in BSAP provides an additional level of security be ensuring that messages are not assumed to have arrived at their destination. All messages initiated by a node are acknowledged by the receiving node. If an acknowledgment is not received the message is assumed not to have arrived. Also, a unique serial number is assigned to all messages to ensure that a response is matched to a specific request.

Within a network it is essential that certain communications take precedent over others. BSAP prioritizes communication messages such that commands being sent down the network,

NETWORK 3000
BSAP
BRISTOL STANDARD ASYNCHRONOUS PROTOCOL

SPECIFICATION SUMMARY D454SS-6a

ie. to change set points or turn outputs on or off, have the highest priority and interrupt the normal polling cycle. Alarms have the highest priority of all messages traversing up the network but do not interrupt the normal polling cycle.

Specifications

- **SO 1745/2111/2629**
  1745 - asynchronous character oriented
  2111 - transparent messages
  2629 - conversational mode
- **Protocol layering**
  Physical level
  Link level
  Network level
  Transport end-to-end
- **Message length**
  variable up to 253 bytes
- **Data lengths**
  Analog - 4 bytes (floating point)
  Logical - 1 byte
  Packed logical - 8 values/byte
  Alarm time stamp - 5 bytes
  Alarm data - 6 to 10 bytes
- **Addressing**
  local and global
- **Network levels supported**
  6 levels
- **Nodes per level**
  Up to 127 nodes from each existing node at a level. In a property configured network, one level could contain several thousand nodes.
- **Communication modes**
  peer to peer
  Remote Data Base access (RDB)
  Report By Exception (RBE)
- **Alarm handling**
  Automatic
- **Message security**
  16 bit CRC-CCITT
- **Supported communication rates**
  Synchronous - 187.5 Kbaud, 1 Mbaud
  Asynchronous - 300 baud to 38.4 K baud
- **Line media supported**
  RS 423, RS 485 multidrop
  Leased phone line
  Dial up phone line
  Satellite
  Single and redundant coax
  Fiber optic

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SPECIFICATION SUMMARY

D456 SS-0d

DPC 3330

DISTRIBUTED PROCESS CONTROLLER

The DPC 3330 is an intelligent distributed process controller. It has been designed specifically to apply to a range of uses:

Any multi-loop continuous control application, up to 16 loops, including feed forward, cascade, adaptive gain, ratio, override, auto-selector, multivariable, ramp and rate;

Logic control, up to 96 DI/DO, including motor start/stop, pump rotation and sequencing, interlocks, failure/alternation, peak handling, timing, stepping, and scheduling;

Batch processing, including sequence and logic control, ramping, timing, recipe selection, and interlocks;

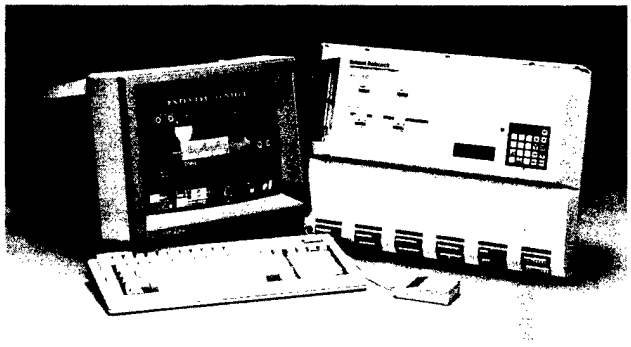
Calculations such as corrected flow computations (AGA3, AGA5, AGA7, AGA8, NX19), efficiency, averaging, totalizing, and process simulation;

The DPC 3330, using the multitasking ACCOL II language, provides the capability to perform all such functions in the same program, thus allowing complex requirements to be satisfied.

For larger I/O requirements the DPC 3330 will support ten RIO 3331 Remote I/O racks, with a total of 50 I/O cards. Each RIO 3331 will accommodate up to ten process I/O cards. The RIO 3331's connect to the DPC 3330 via RS485. No communication programming is required for this connection.

The DPC 3330 provides the capability necessary for applications where PLCs and RTUs are too limited and distributed process control systems are too expensive. It fulfills the need for a microprocessor-based unit in the gas pipeline, water, and process industries.

The DPC 3330 can be used as a pure standalone device or can be networked to other DPC 3330's as well as other members of Bristol's Network 3000 product family. These include single loop controllers, RTUs, remote distributed controllers, gas flow computers, smart transmitters and personal computers or minicomputers used as operator interfaces. In addition, the DPC 3330 can be networked with popular PLCs, RTUs, flow computers, and smart transmitters from other vendors.



DPC 3330 with an IBM Personal Computer running Genesis

The DPC 3330 can also utilize peripheral devices, including a built-in display/keypad, extended display/keypad, hand-held terminal, laptop computer, operator display terminal, printer, and chromatograph. In fact, virtually any serial ASCII device can be accommodated.

By interfacing to a variety of process input/output signal types, including all the standards used in measurement and control, the DPC 3330 can be wired into most any instrumentation system.

The DPC 3330 employs a modular design making use of CMOS electronics and large scale integrated circuits such as ASICs. This provides maximum reliability and serviceability as well as minimum power dissipation. In case a hardware problem does occur, firmware-based built-in diagnostics, which run on-line, will detect the fault.

The DPC 3330 is programmed using ACCOL II, Bristol's advanced control and communication language. A modular, multitasking system, ACCOL II far surpasses commonly-used languages such as BASIC, function block, and ladder logic; it allows the 3330 to perform the same functions as much more expensive digital process control systems. A comprehensive software product line, that includes menu-driven configuration, program downloading/uploading via the network, software

DPC 3330
DISTRIBUTED PROCESS CONTROLLER

SPECIFICATION SUMMARY D456 SS-0d

debugging, communication and hardware diagnostics, and program documentation, provides the tools necessary to maximize the utility of the DPC 3330.

FEATURES

- Stand-alone or distributed process controller
- Low power consumption
- Powerful 16-bit CMOS 186XL processor
- Optional CMOS 80C187 numeric co-processor
- Up to 512 K bytes EPROM
- 128 K or 384 K bytes RAM
- RAM memory battery back-up
- Up to four serial I/O ports for RS423/RS485 communication
- Asynchronous baud rates up to 38.4 K baud
- Synchronous baud rates at 187.5 K baud and 1 M baud
- Built-in modems (private line, dial-up, or fiber optic)
- NEMA 4 enclosures available
- Two package sizes accommodate up to six or twelve rugged process I/O subsystems in any combination of the following:
  - Digital In (8DI)
  - Digital Out (8DO)
  - Analog In (4AI)
  - Analog Out (2AO)
  - High Speed Counter in (4HSC)
  - Low level in (4LL)
  - High Speed Analog In (4HSAI)
  - Honeywell Smart Transmitter Interface (8 smart transmitters)
- Remote I/O - RIO 3331
- Pluggable I/O terminations
- LED indicators on the Digital I/O modules
- Operating temperature range: -40° C to 70° C
- Optional LCD display with Keypad (built-in or extended)
- Uses ACCOL II modular high-level control language

SPECIFICATIONS

The DPC 3330 design incorporates the processing power, communication capability, I/O adaptability, software configurability, and environmental suitability necessary for today's industry needs. It provides these in a low-cost, reliable, very serviceable unit.

PROCESSING POWER

- Processor: 16 bit CMOS 186XL microprocessor
- Speed: 12 MHz or 20 MHz
- Coprocessor: Optional CMOS 80C187 floating-point numeric processor
- Firmware EPROM: 512 K bytes
- RAM: 128 K, or 384 K bytes static RAM
- 4000 hour RAM battery back-up
- Real Time Clock: DS1287, accurate to one second/day
- 6 diagnostic LEDS
- Watchdog LED
- Idle LED
- Watchdog timer, relay, and contacts
- Switchover output for back-up SLC
- Address DIP Switch for network address (range: 1 to 127)
- Optional 64 K PROM used in place of RAM for PROM-resident ACCOL program

COMMUNICATION CAPABILITY

- 2 serial ports standard
- 2 additional serial ports optional
- RS423/RS485 selectable per port
- Media: multiconductor cable
- Cable length (at 9600 baud): 1000 feet (RS423), 2000 feet (RS485); at 187.5 K baud: 1000 feet (RS485); at 1 M baud: 200 feet (RS 485), 5000 feet node-to-node (fiber), 8680 feet maximum (coaxial)
- Multidrop: 32 nodes using RS485; point-to-point, only, for RS423
- Asynchronous communication, on all ports
- High speed synchronous communication up to 4 ports
- Asychronous baud rates, selectable per port: 300, 1200, 2400, 4800, 9600, 19200, and 38400
- Asynchronous cold download baud rates:
  - Ports A&C - fixed at 9600 baud
  - Ports B&D - switch selectable (1200, 2400, 4800, 9600, 19200, 38400)
- Synchronous baud rate: 187.5 K and 1 M baud (multidrop: RS485 and coaxial; point-to-point, only, for fiber optic)
- Program downloading/uploading can be accomplished via synchronous or asynchronous communication

Redundant Automatic Switchover Communications Link (RASCL)

- 1 M baud communication
- Provides redundant physical connection between 2 or more controllers
- Single or dual link configurations
- Uses low cost 75 Ohm coaxial cable
- Up to 8680 feet node to node connection
- Node to line islolation of 2000 Vac

Refer to specification summary D461SS-1

Modems:

- Optional one or two built-in modems connect to RS423/RS485 ports
- Modem baud rate: 300 or 1200, selectable per modem
- Three types of modems are available:
  - Private line modem for leased lines or radio keying
  - Switched network modem for auto-dial/auto-answer
  - Fiber optic modem

Refer to specification summaries D461SS-2, D461SS-3, D461SS-4

Transmitter Interface Board (TIB)

- Optional, integral, plug-in board connects to RS423/485 ports (B&D)
- Each TIB allows up to five 3508 smart transmitters to function as slaves to a DPC 3330
- Communicates at 1200 baud
- Polling speed: One transmitter per second
- Provides 24 volt loop power required by the 3508

Refer to specification summary D461SS-6

Radio Delay Interface Board (RDI)

- Radio and satellite communication delay board
- Optional, integral, plug-in board connects to RS423/485 ports (B&D)
- Provides RS232 interface to an external radio modem or transceiver
- Three timing functions available:
  - Leading Edge Delay (RTS-to-CTS Delay)
  - Trailing Edge Delay
  - Carrier Time Out

Refer to specification summary D461SS-5

Multipurpose Interface Board (MIB)

- Plug-in board - connects to port B or D
- Can be configured to operate in two communication modes
- Mode 1: provides network termination and surge protection for RS485 networks
- Mode 2: functions as a redundant physical link; both RS485 links carry the same data from port B or D
- Not used with RS423 or modems

Refer to specification summary D461 SS-7

COMMUNICATION PROTOCOLS/ MESSAGE STRUCTURES

BSAP

- Bristol Standard Asynchronous Protocol
- ISO Standard 1745/2111/2629
- Used to network Bristol products, including the SLC 3755, RTU 3310, DPC 3330, DPC 3335, RIO 3331, GFC 3308 and 3508 smart transmitters
- Local addressing: 127 nodes
- Global addressing: 32,767 nodes (via pass-through nodes)
- Hierarchy: 5 levels
- Contention Scheme: Polled
- Programming: Via standard master and slave ACCOL software modules

Refer to specification summary D454SS-6a

ASCII

- Simple ASCII, with selectable start, stop, parity, and word format
- Used for communication with RTU 3301's and peripheral devices such as computers, printers, graphic terminals, displays, and handheld terminals
- Input and output
- Programming: Standard ACCOL Logger module uses a complete set of format commands for message configuration, handshaking, display formatting, and printed report formatting

OTHER PROTOCOLS

- Allen Bradley PLC-2, standard
- Modbus, including Daniel Solarflow Plus and 2500 variations, standard
- Adept protocol, optional
- Columbia Natural Gas (ANSI 3.28), optional
- El Paso Natural Gas, standard
- Teledyne-Geotech, standard
- Protocols are selectable on a per-port basis; a DPC 3330 can use multiple protocols (on different ports) simultaneously
- Several others also available
- Protocols are available on optional custom protocol PROM

ENVIRONMENTAL SUITABILITY

Despite the very modern appearance of the standard DPC 3330 package, it is extremely rugged. The case is made from injection molded Lexan, a very sturdy material used in products that must be impact-proof.

The DPC 3330 is Factory Mutual certified, meets SAMA specifications for vibration, and meets IEEE-472/C37.90 surge protection criteria.

The modular "no-cables" design makes the DPC 3330 package very easy to install and service.

- Operating Temperature: -40° C to 70° C
- Display/keypad: -20° C to 70° C
- Low Level AI Board: 0° C to 70° C
- High Speed AI Board: -20° C to +70° C
- Storage Temperature: -40° C to 85° C
- Relative Humidity: 5% to 95% noncondensing
- RFI Susceptibility: per SAMA standard PMC 33.1-1978, using field of 10 V/m from 20 MHz to 500 MHz
- Vibration: Rated for field mount applications.
  15-150 Hz @ 9.8 m/s² (1G) constant acceleration
  150-2000 Hz @ 4.9 m/s² (.5G) constant acceleration
- Cooling: Not required (natural convection)
- NEMA rating: Standard package not rated, but similar to NEMA I; optional NEMA 4 enclosure
- Approval: FM and CSA certified as nonincendive for

DPC 3330
DISTRIBUTED PROCESS CONTROLLER

SPECIFICATION SUMMARY D456 SS-0d

Class I, Division 2, Groups A-D installations

PACKAGING

Standard Package is relay rack or panel/wall-mounting (please refer to diagram for mounting); As the diagram shows, the package mounts in a manner that allows room for wiring above and below the unit. Cable trays can be placed in these positions to allow routing of wires to the side and out to other equipment. NEMA 4 enclosure is set-up for wall mounting.

Three packages are available:
- 0-slot ("Data Concentrator")
- 6-slot (6 I/O card capacity)
- 12-slot (12 I/O card capacity)

DIMENSIONS

0-slot:
7"L x 19"W x 5-1/2"D Standard
18"L x 24"W x 8"D NEMA 4

6 slot:
13-1/2" L x 19"W x 5-1/2"D Standard
18"L x 24"W x 8"D NEMA 4

12 slot:
19-1/2"L x 19"W x 5-1/2"D Standard
24"L x 24"W x 8"D NEMA 4

WEIGHT

0-slot:
11 lbs. Standard
31 lbs. NEMA 4

6-slot:
14 lbs. Standard
34 lbs. NEMA 4

12-slot:
17 lbs. Standard
44 lbs. NEMA 4

POWER REQUIREMENTS

Two power supplies (DC-DC converters) are available:
- 12 Vdc input
- 24 Vdc input

Supply Input:
- 24 Vdc Type: 22-28 Vdc
- 12 Vdc Type: 9-18 Vdc

Maximum input noise: 2.0 V p-p

Typical Power Requirements (@ 24 Vdc)

	Watts	Amps at 24 Vdc
12 MHz CPU Board*	1.50	.063
20 MHz CPU Board*	2.00	.080
System Interconnect Board*	3.00	.120
Comm. Board (2 Ports)*	1.10	.045
Enhanced Comm. Board	2.00	.080
Display/Keypad (Local)	0.15	.006
Display/Keypad (Ext)	0.20	.008
Math Coprocessor	0.60	.025
AI Board	0.44	.018
AO Board	0.68	.028
DI Board w/LED	0.15	.006
DI Board w/o LED	0.04	.002
DO Board w/LED	0.15	.006
DO Board w/o LED	0.04	.002
HSC Board w/LED	0.22	.009
HSC Board w/o LED	0.12	.005
Low Level Board	1.40	.058
HSAI Board	1.40	.058
DO Relay Board w/LED	0.10	.004
DO Relay w/o LED	0.04	.002
C.B.O. Board	4.50	.190
HWSTI Board	2.20	.090
Modem	0.63	.026
RDI Board	0.10	.004
TIB Board	0.73	.030
RASCL	3.00	.125
MIB	0.50	.021

*Part of the base unit

NOTE: The above figures do not include loop power. To account for the additional power draw of external devices, such as transmitters, add the following for each point:

	Watts	Amps at 24 Vdc per input point
DI Board	.12	.005
HSC Board	.12	.005
DO Relay Board	.25	.010
AI Board	.50	.020
AO Board	.50	.020
HWSTI Board	.30	.012

SOFTWARE CONFIGURABILITY

The DPC 3330 uses ACCOL II, Bristol's high-level, modular process control language.

ACCOL II features:
- o 90 high-level modules (algorithms)
- o 23 calculator module functions

DPC 3330
DISTRIBUTED PROCESS CONTROLLER

SPECIFICATION SUMMARY D456 SS-0d

- o 12 programming statements ("sequence extensions")
- o Multitasking: 127 tasks per DPC 3330
- o Task execution intervals: 0.02 to 5400 seconds or continuous, selectable per task
- o 9999 ACCOL modules per task
- o Analog (32 bit floating point), discrete (on/off) and string variables
- o Alarm/Exception reporting: state for logical values, four limits and two deadbands for analog values
- o Alarm/Event message storage: up to 4096 messages in RAM; 16 bytes per message
- o Data base storage: Data arrays - 4 bytes per stored value; up to 32 K bytes per array. Storage arrays: 12 values per 64 byte record; up to 256 K bytes of total array space.

Refer to specification summary D454SS-5a

SOFTWARE PACKAGES

The following software packages are pertinent to the DPC 3330:

ACCOL II Interactive Compiler (AIC)-Provides a fill-in-the-blanks menu system for configuration of ACCOL II programs. Includes on-line modification, linking, program downloading, and a documenter.

ACCOL II Batch Compiler (ABC)-Allows ACCOL II program creation and modification using a text editor. Useful in conjunction with the AIC.

Toolkit-A menu-driven, on-line software debug tool and hardware/communication diagnostic program.

Universal Operator Interface (UOI) - Provides a customizable, menu-driven operator interface to a DPC 3330. Collects on-line, historical and audit trail data for storage and reporting.

NOTE: The off-line programs require DOS/IBM PC or VAX/VMS compatible. The on-line programs require DOS/IBM PC or VAX/VMS with Enterprise server.

Genesis-Provides a comprehensive PC-based operator interface for a DPC 3330 or network of DPC 3330's; provides color graphic displays, alarm reporting, printed reports, and historical data base.

Enterprise-Provides a comprehensive, multi-user operator interface for a network of DPC 3330's. VAX/VMS compatible. Suitable for large systems with up to 64,000 data points.

I/O ADAPTABILITY

The DPC 3330 provides interfacing to a wide variety of wiring present in measurement and process control systems. All the "standard" signal ranges are included.

SPECIFICATIONS COMMON TO ALL I/O

- o Pluggable terminal blocks
- o Screw compressor terminations accommodate up to 12 AWG wire
- o 24 Vdc loop power available at terminations (not available in 12 Vdc powered units)
- o Hardware selectable ranges/options
- o Single boards include both terminations and interfacing electronics
- o Surge protection meets IEEE 472-1974 and C37.90-1978 (revision, 1983)

ANALOG INPUTS

- o 4 board types are available
- o Differential inputs
- o 12 bit A/D converter per board
- o Conversion time: 200 µs
- o Accuracy (all ranges):
  - 0.1% at 25° C
  - 0.2% over -20° C to 70° C
  - 0.3% over -40° C to 70° C
- o Input filtering: single pole 50 ms time constant: 300 msec to 0.1% of input value
- o Setting time: 18 µs to 0.01%
- o Software filtering: fully programmable in ACCOL II
- o Input sampling: depends on ACCOL task interval (0.02 to 5400 seconds)
- o Surge protection:

Board Code	Input Quantity	Input Range	Input Impedance	Common Mode Voltage	Surge Protection
1	4	0-10 Vdc	150 K ohms	+2 V, -12 V	± 39 Vdc
2	4	1-5 Vdc	150 K ohms	+5 V, -10 V	± 39 Vdc
		4-20 mA	250 ohms	+5 V, -10 V	± 39 Vdc
3	4	0-10 Vdc	2 Meg ohms	180V	±180 Vdc
4	4	1-5 Vdc	2 Meg ohms	180V	±180 Vdc
		4-20 mA	250 ohms	180V	±180 Vdc

1-5 Vdc/4-20 mA selectable per point

ANALOG OUTPUTS

- o 2 board types are available
- o 12 bit D/A converter per board
- o Accuracy (all ranges):
  - 0.1% at 25° C
  - 0.2% over -20° C to 70° C
  - 0.3% over -40° C to 70° C
- o Surge protection: 15 V transorbs between analog output and analog common; 39 Vdc MOVs between analog common and chassis ground

Signal conditioning: 100 µs time constant for 1-5 Vdc/4-20 mA outputs; 6.5 µs time constant for 0-10 V outputs
Update interval: Software configurable (ACCOL task interval, 0.02 to 5400 seconds).

DPC 3330
DISTRIBUTED PROCESS CONTROLLER

SPECIFICATION SUMMARY D456 SS-0d

Board Code	Output Quantity	Output Range	Impedance
6	2	0-10 Vdc	5 mA source
7	2	1-5 Vdc	5 mA source
		4-20 mA	0 to 650 ohms

1-5 Vdc/4-20 mA selectable per point

LOW LEVEL INPUTS

- o Operating Range: 0° C to 70° C
- o 4 inputs per board
- o All ranges selectable per point
- o 14-bit A/D via successive approximation
- o 16-bit on board microprocessor
- o 32 K bytes EPROM
- o 32 K bytes RAM

INPUT TYPES

Thermocouples	Range
B	100 to 1800° C
E	-270 to 1000° C
R	-50 to 1720° C
S	-50 to 1760° C
J	-210 to 1200° C
K	-270 to 1372° C
T	-270 to 400° C

ACCURACY
See Table below

Thermocouples		Resolution	25°C	Accuracy 0°C to +70°C
B	100 to 200°C	2.0°C	±8°C	± 16°C
	200 to 390°C	1.0°C	±4°C	± 8°C
	390 to 840°C	0.5°C	±2°C	± 4°C
	840 to 1800°C	0.2°C	±1°C	± 2°C
E	-270 to -260°C	1.0°C	±3°C	± 6°C
	-260 to -225°C	0.25°C	±1°C	± 2°C
	-225 to -200°C	0.08°C	±.75°C	± 1.5°C
	-200 to 1000°C	0.09°C	±.5°C	± 1°C
R	-50 to +50°C	0.4°C	±2°C	± 4°C
	50 to 1720°C	0.17°C	±1°C	± 2°C
S	-50 to +50°C	0.37°C	±2°C	± 4°C
	50 to 1760°C	0.18°C	±1°C	± 2°C
J	-210 to 191°C	0.08°C	±.75°C	± 1.5°C
	-190 to 1200°C	0.11°C	±.5°C	± 1°C
K	-270 to -261°C	2°C	±5°C	± 10°C
	-260 to 246°C	0.56°C	±2°C	± 4°C
	-245 to 180°C	0.25°C	±1°C	± 2°C
	-179 to -145°C	0.08°C	±.75°C	± 1.5°C
	-145 to 1372°C	0.14°C	±.5°C	± 1°C
T	-270 to -261°C	1.5°C	±4°C	± 8°C
	-260 to -251°C	0.38°C	±2°C	± 4°C
	-180 to -136°C	0.08°C	±.75°C	± 1.5°C
	-135 to 400°C	0.06°C	±.5°C	± 1°C
RTD	-220 to 850°C	0.09°C	±.25°C	± .5°C
±10mV			±.025%	± .05%

RTD
100 Ω platinum Din 43670 - 220 to 850°C

VOLTAGE
±10mV

INPUT RESISTANCE
10 Meg Ohms

SIGNAL CONDITIONING
50 ms time constant

ISOLATION-COMMON MODE
500 V peak w/isolation amplifiers

SURGE PROTECTION
IEEE 472-1974
C37.90-1978

HIGH SPEED ANALOG INPUTS

- o Operating range: -20° C to 70° C
- o 4 analog inputs (process variables)
- o 2 discrete inputs (timing signals)
- o HPC 36003 16-bit microprocessor
- o 32 K RAM and 32 K EPROM
- o 10 µs input conversion
- o 360/1440 data input samples (conversions) per input cycle

AI specs:
- o Input ranges (jumper selectable): 1-5 Vdc and 4-20mA
- o Input sourcing: 24 Vdc, jumper selectable, for 4-20 mA loop power
- o A/D resolution: 12 bits
- o Accuracy: 0.1% at 25° C
  0.2% over -20° C to 70° C
  0.3% over - 40°C to 70°C

DI specs:
- o Input range: 5 V
- o Off/on threshold: 0.5 V/4.5 V

Refer to Specification Summary D456 SS-4.

DISCRETE INPUTS

- o 5 board types are available
- o Isolation: Optical isolation; 1500 V common mode isolation
- o Dry contact inputs: Accommodated by jumper selectable internal/external loop power
- o Indicator: LED ("on" status); can be disabled
- o Counter inputs: Interrupt-driven; maximum 300 Hz on a single input, 800 Hz total pulses on all inputs, can be accommodated by the DI boards; Accumulator or frequency mode selectable in ACCOL software

DPC 3330
DISTRIBUTED PROCESS CONTROLLER

SPECIFICATION SUMMARY D456 SS-0d

- o PDM input ranges:
  Bristol 5 second (1 to 4 sec);
  Bristol 15 second (3 to 12 sec);
  BIF 15 second (0 to 13.33 sec);
  BIF 60 second (0 to 53.3 sec)
- o PDM input variables scaled in ACCOL software

Board Code	Input Quantity	Input Range	Off/On Threshold	Filter Time Constant
K	8	5 Vac/dc	0.5V/4.5V	1 ms*
R	8	12 Vac/dc	1.2V/10.8V	1 ms*
A	8	24 Vac/dc	2.4V/21.6V	1 ms*
B	8	12 Vac/dc	1.2V/10.8V	30 ms
C	8	24 Vac/dc	2.4V/21.6V	30 ms
D	4	120Vac/dc	12V/108V	30 ms

*The 1 msec is appropriate to PDM inputs from Metamaters. It must also be used for low speed counter applications.

DISCRETE OUTPUTS

- o 3 board types are available
- o Relay contact rating:
  2A resistive 50 Vdc or 120 Vac 50/60 Hz
  0.6A inductive 50 Vdc or 120 Vac 50/60 Hz
  0.4A motor 50 Vdc or 120 Vac 50/60 Hz
  0.2A lamp 50 Vdc or 120 Vac 50/60 Hz
- o Indicator: LED ("on" status); can be disabled
- o Output modes: Programmable via ACCOL
  On/off latch;
  Momentary;*
  Counter/Pulse;*
  PDM;
  PDO: (Raise/lower pulse duration) with resolutions selectable: 20 ms, 50 ms, 100 ms

*durations and frequencies depend on ACCOL task interval (0.02 to 5400 sec)

Board Code	Output Quantity	Output Type	Source/ Range
E	8	Open Collector	100 mA @ 35 Vdc
F	4	Relay	24 V Coil
M	4	Relay	12 V Coil

CHECK BEFORE OPERATE (CBO) DISCRETE OUTPUTS

- o Provides a reliability check on discrete outputs
- o Eight outputs per board
- o Three board types available
  - Relays with surge protection
  - Relays with fusing
  - External relays
- o CBO Relay Module mounts on an external DIN support rail and connects to the CBO I/O card via a ribbon cable

Refer to specification summary D462SS-2

HIGH SPEED COUNTER INPUTS

- o 3 board types are available
- o Frequency range: 0 to 10 KHz
- o Selectable internal/external loop power for dry contact inputs
- o Debounce circuitry: can be enable or disabled
- o Set, Reset, Common, and Shield terminals per input
- o Isolation: Optical isolation; 1500 V common mode isolation
- o Indicator: LED ("on" status); can be disabled

Board Code	Input Quantity	Input Range	Off/On Threshold	Current Draw
G	4	24 V	2.4V/21.6V	5 mA
H	4	12 V	1.2V/10.8V	5 mA
N	4	5 V	0.5V/4.5V	5 mA

HONEYWELL SMARTLINE TRANSMITER INTERFACE BOARD (HWSTI)

- o Provides eight independent, bi-directional communication channels
- o Each channel allows a Honeywell ST3000 transmitter to communicate with a DPC 3330
- o Ground-referenced transmitter power for each input channel
- o Plugs into any I/O slot
- o Field Termination Assembly (FTA) mounts on an external DIN support rail and connects to the HWSTI via a ribbon cable

Refer to specification summary D462SS-1

ACCESSORIES

DISPLAY/KEYPAD

- o Operating range: -20° C to 70° C
- o 4 line by 20 character backlit liquid crystal display
- o 5 x 5 keyboard matrix
- o Local unit mounts on front panel of standard package
- o Extended unit mounts on a front panel; connects via a 10 foot ribbon cable
- o Field retrofittable
- o Parallel interface to I/O bus
- o Supported by menu display system in firmware
- o Programming: Via ACCOL module; consists of specification of signal lists to be accessed by the menu system

Refer to specification summary D456SS-3a

HANDHELD TERMINAL (HHT)

- o 4 line by 16 character liquid crystal display
- o Numeric/function keypad
- o RS422 serial interface, uses a DPC 3330 serial port
- o Can be extended up to 2000 feet away from the DPC 3330

- Programming: Via ACCOL logger module and format commands; completely programmable, as required
- Two models are available:
  With memory (32 K bytes RAM): allows data base transfer between DPC 3330 and HHT; without memory: operator interface only

Refer to specification summary D452SS-4a

SERIAL PRINTER

- Any serial printer can be connected to an RS423 port
- Programming: Via ACCOL logger module and format commands; log format is completely programmable

OPERATOR TERMINAL

- Any serial ASCII terminal can be connected to an RS423 port
- Programming: Via ACCOL logger module and format commands; display format and keyboard input are completely programmable

NETWORK INTERFACE BOARD (NIB)

- Required for network termination and surge protection in RS485 networks
- Not used with RS423 or modems

Refer to Specification Summary D456 SS-2a

Bristol Babcock

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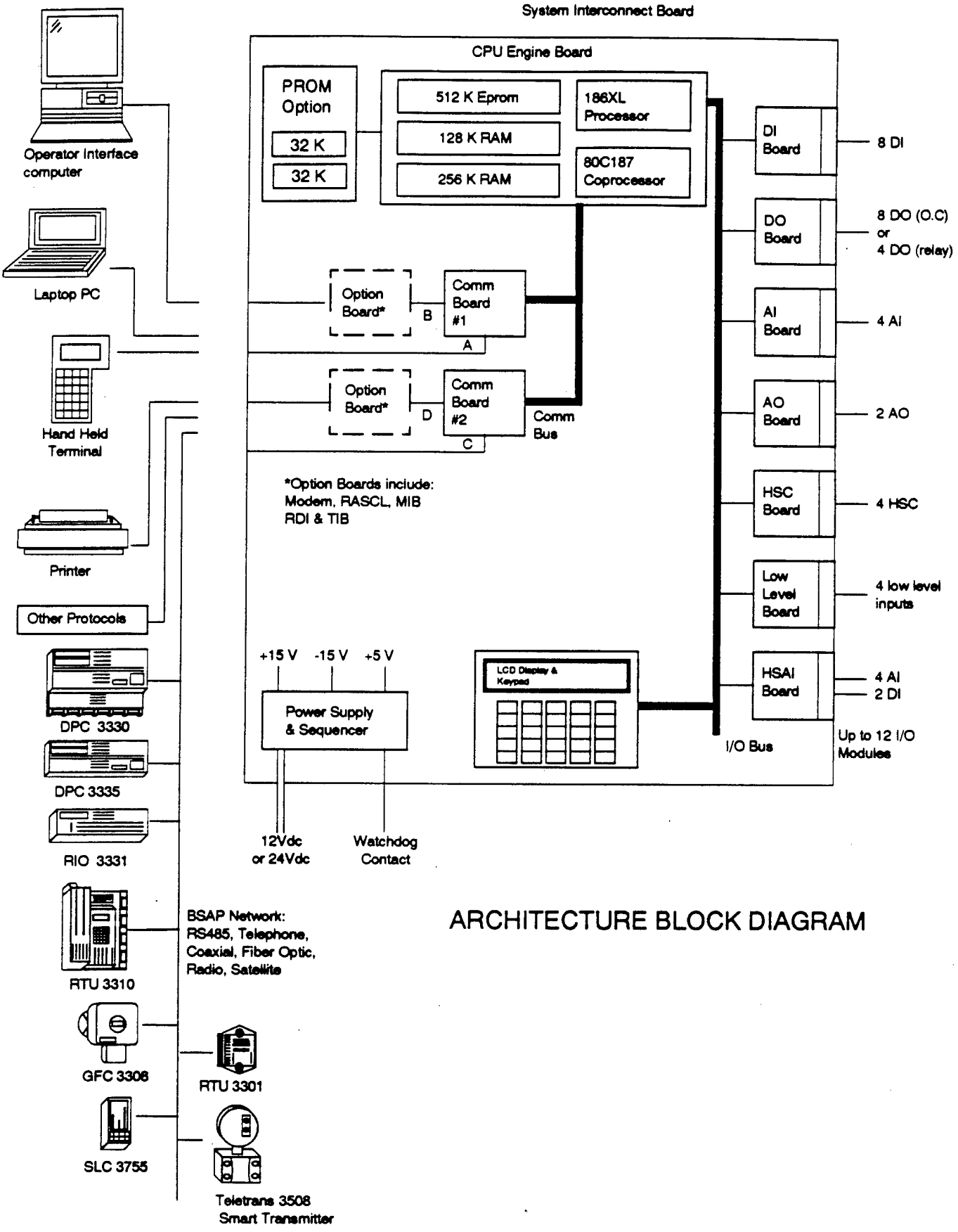
DPC 3330
DISTRIBUTED PROCESS CONTROLLER

SPECIFICATION SUMMARY

D456 SS-0d

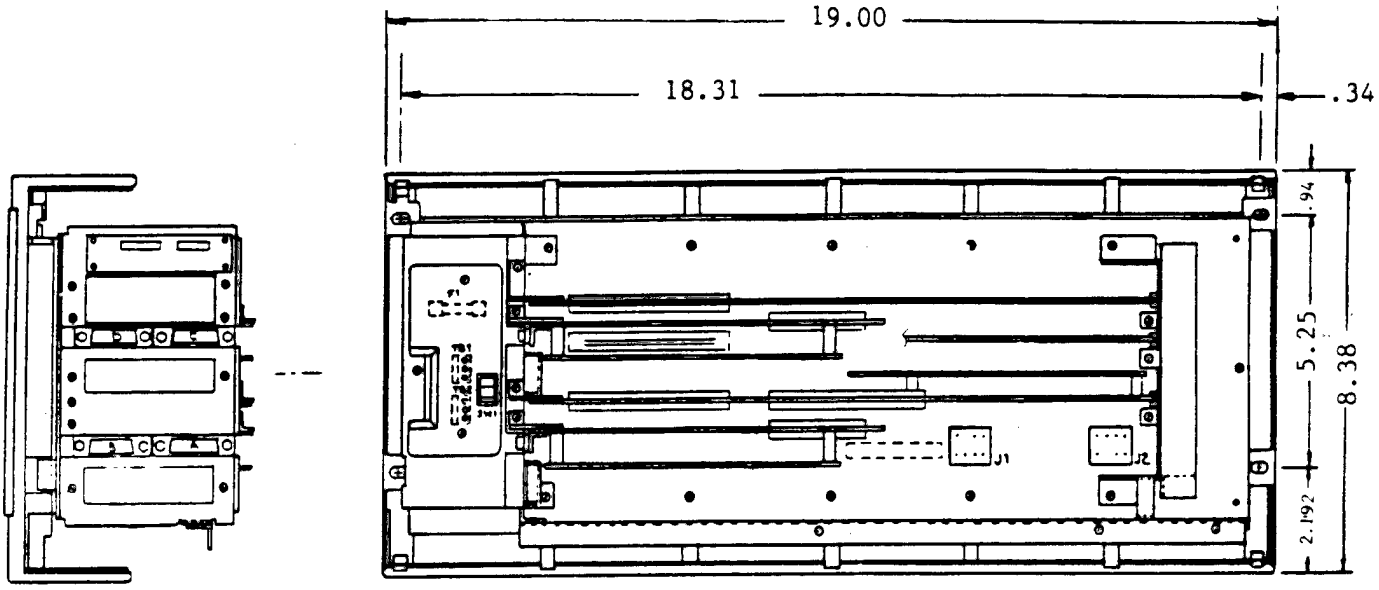


ARCHITECTURE BLOCK DIAGRAM

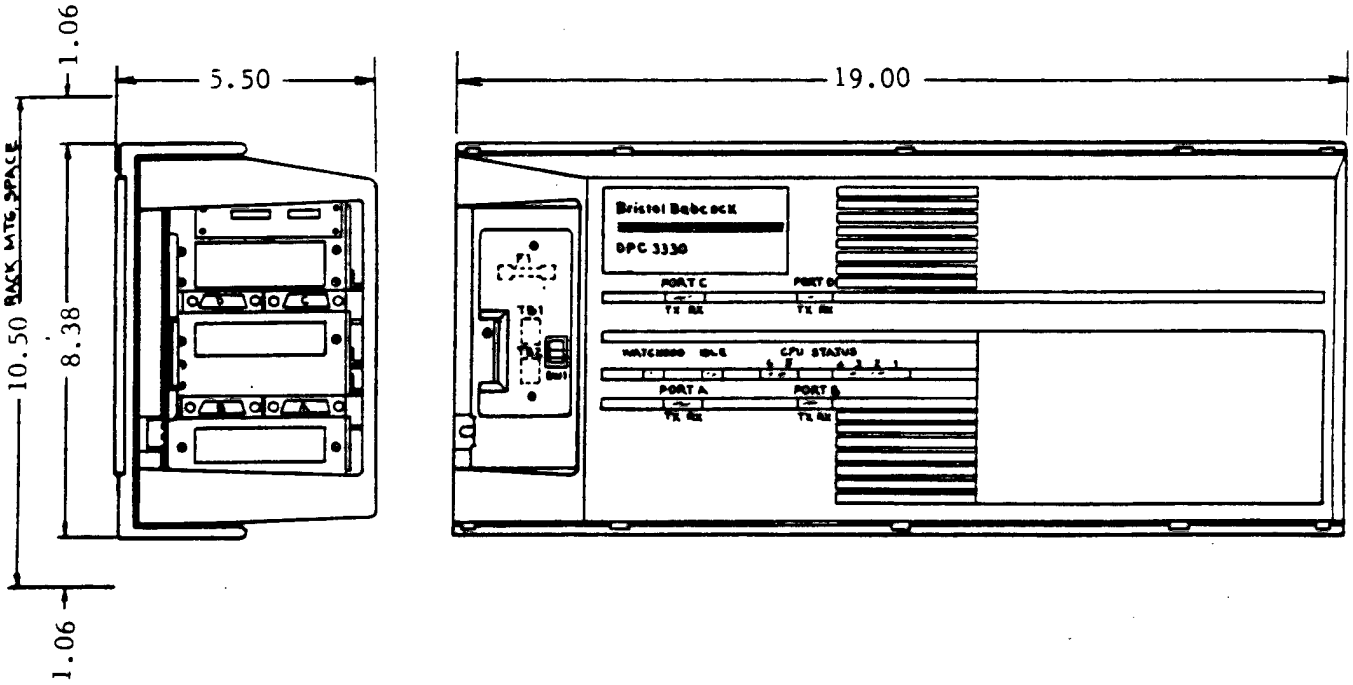
DPC 3330
DISTRIBUTED PROCESS CONTROLLER

SPECIFICATION SUMMARY

D456 SS-0d



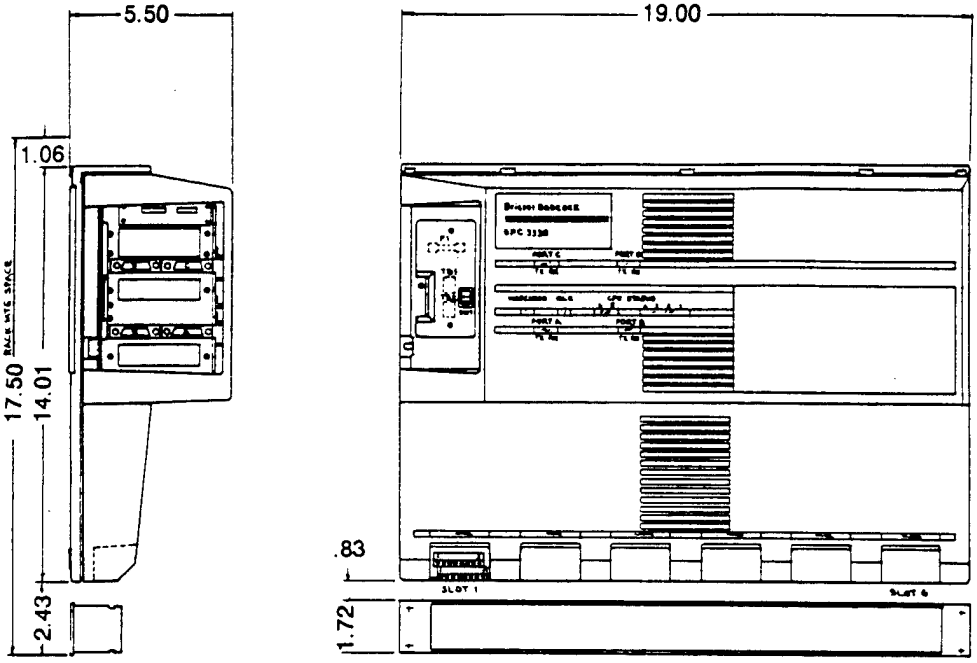
DPC 3330- O SLOT
(DATA CONCENTRATOR)



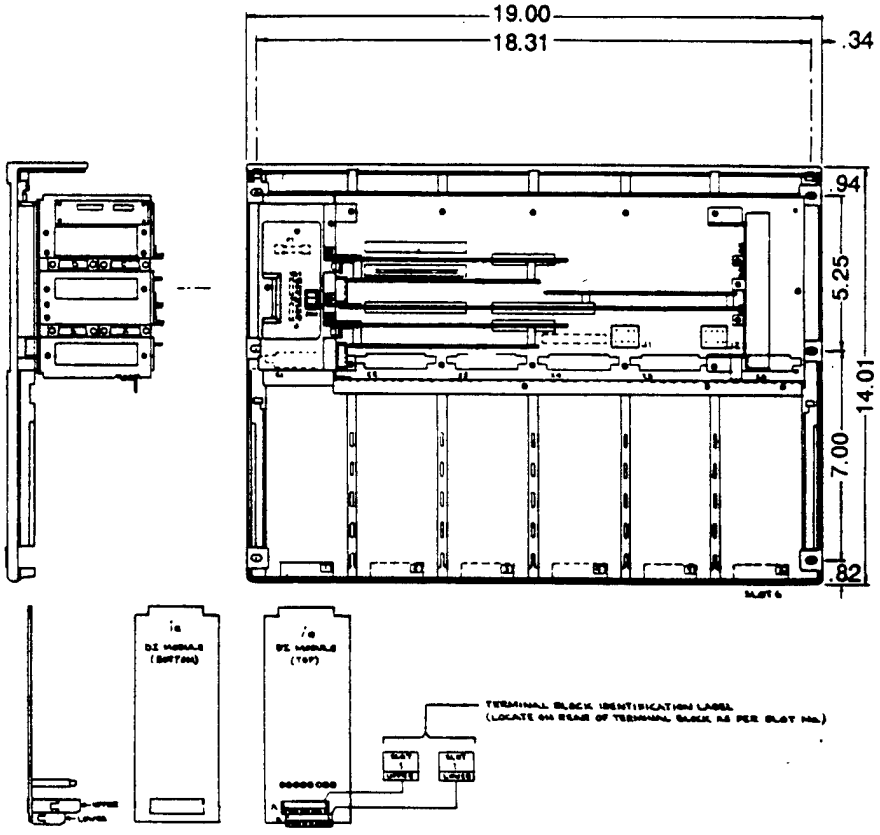
DPC 3330
DISTRIBUTED PROCESS CONTROLLER

SPECIFICATION SUMMARY

D456 SS-0d



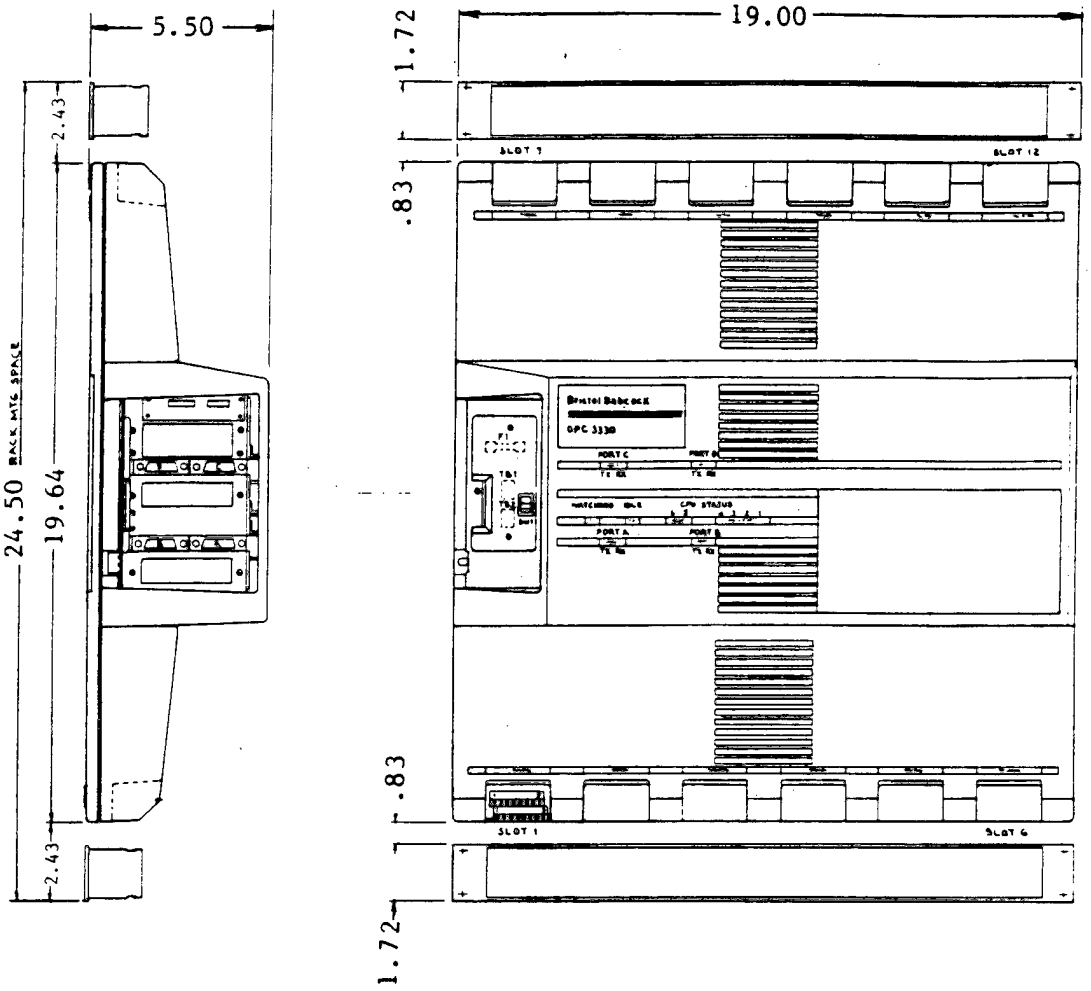
DPC 3330 - 6 SLOT I/O



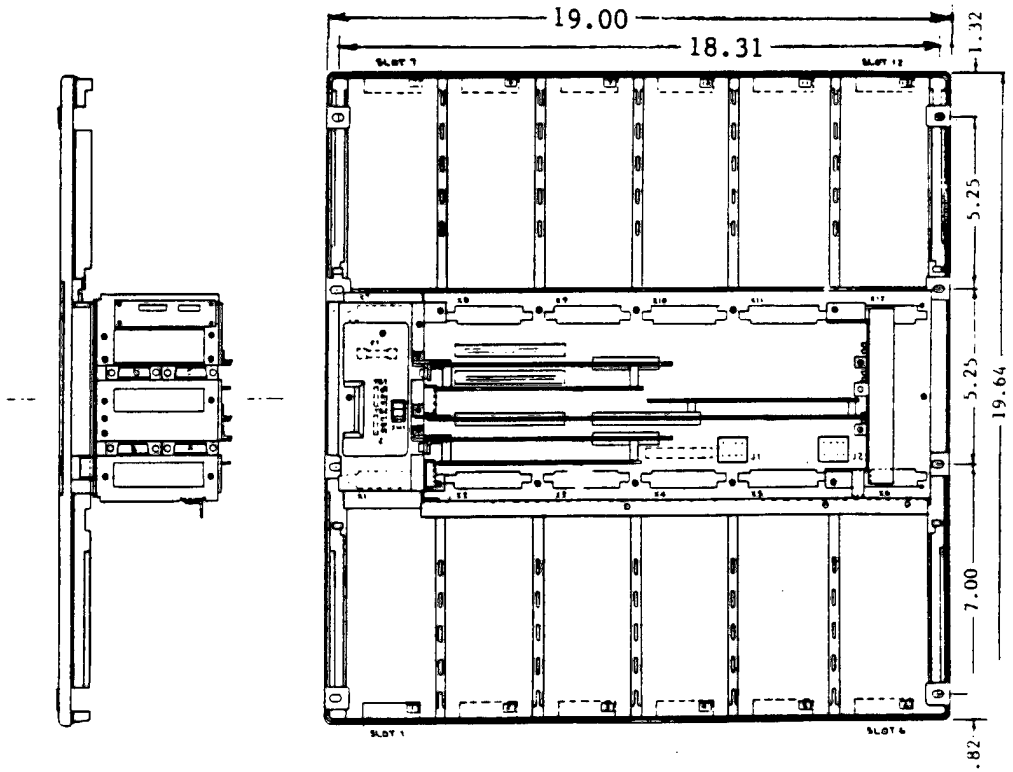
DPC 3330
DISTRIBUTED PROCESS CONTROLLER

SPECIFICATION SUMMARY

D456 SS-0d



DPC 3330 - 12 SLOT I/O



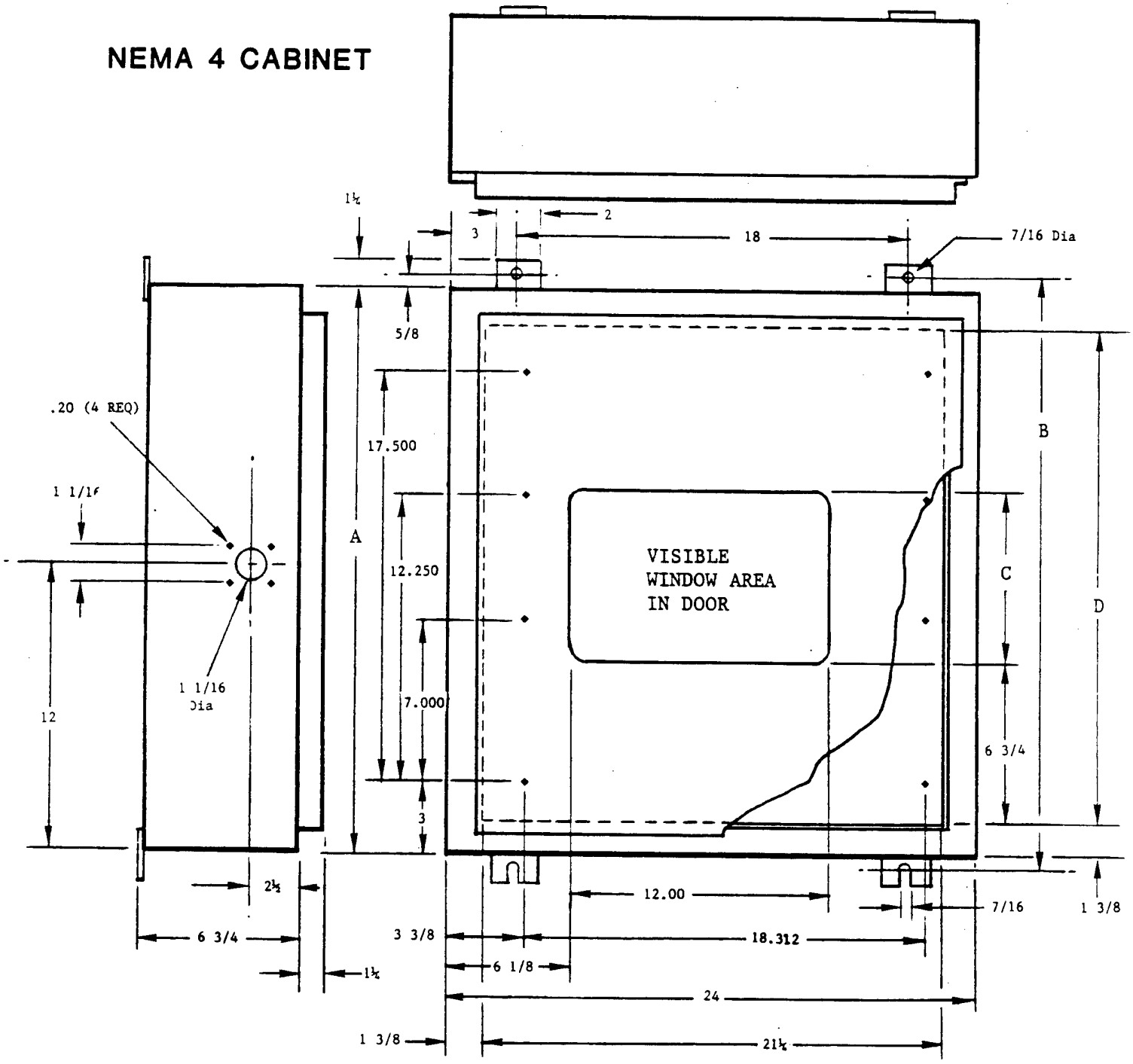
DPC 3330
DISTRIBUTED PROCESS CONTROLLER

SPECIFICATION SUMMARY

D456 SS-0d

Bristol P/N	Status	A	B	C	D	Item 1 REQ
389900-02-8	1 a	24	25½	7 1/8	21½	8
389900-01-0	1 a	16½	17 3/4	4 3/4	13 3/4	6

NEMA 4 CABINET



DPC 3330
DISTRIBUTED PROCESS CONTROLLER

SPECIFICATION SUMMARY

D456 SS-0d

Model Number: 3330-10A - Base (A B C - D E F) - A Attachment - A (A B C - D E F G) - B Attachment - B (#1 #2 #3 #4 #5 #6)

- C Attachment - C (#7 #8 #9 #10 #11 #12) - D Attachment - D (A B C)

BASE				CODE
A	**Base Unit**	12 I/O Slot NEMA 1		1
		12 I/O Slot NEMA 4		2
		6 I/O Slot NEMA 1		3
		6 I/O Slot NEMA 4		4
		0 I/O Slot NEMA 1		5
		0 I/O Slot NEMA 4		6
B	**Internal Power Supply**	+12 VDC	**NOTE 1**	1
		+24 VDC		2
C	**Not Used**	Enter 0 for this selection		0
D	**Certification**	None		0
		FM		1
E F	**Not Used**	Enter 00 for this selection		0 0
ATTACHMENT 3330-A				
A	**Not Used**	Enter 2 for this selection		2
B C	**CPU Options**	**12 MHZ CPU Board**		
		RAM Based	**Floating Point**	
		128K RAM	No	2 2
		384K RAM	No	2 5
		128K RAM	Yes	2 4
		384K RAM	Yes	2 6
		With 64K PROM	**Floating Point**	
		64K RAM	No	3 1
		320K RAM	No	3 5
		64K RAM	Yes	3 3
		320K RAM	Yes	3 6
		20 MHZ CPU Board		
		RAM Based	**Floating Point**	
		128K RAM	No	4 2
		384K RAM	No	4 5
		128K RAM	Yes	4 4
		384K RAM	Yes	4 6
		With 64K PROM	**Floating Point**	
		64K RAM	No	5 1
		320K RAM	No	5 5
		64K RAM	Yes	5 3
		320K RAM	Yes	5 6

Note 1: +24 VDC to power two wire transmitters or relay contacts not available in 12 V 3330s.

DPC 3330
DISTRIBUTED PROCESS CONTROLLER

SPECIFICATION SUMMARY

D456 SS-0d

	Base							Attachment - A							Attachment - B					
	A	*B*	*C*	-	*D*	*E*	*F*	*A*	*B*	*C*	-	*D*	*E*	*F*	*G*	*#1*	*#2*	*#3*	*#4*	*#5*	*#6*
Model Number: 3330-10A -	__	__	__	-	__	__	__	- A __	__	__	-	__	__	__	__	- B __	__	__	__	__	__

	Attachment - C						Attachment - D		
	#7	*#8*	*#9*	*#10*	*#11*	*#12*		*A*	*B*	*C*
- C	__	__	__	__	__	__	- D	__	__	__

ATTACHMENT 3330-A (Continued)					CODE
		Port A	**Port B**		
		RS-423/485	RS-423/485		1
		RS-423/485	Private Line Modem		2
		RS-423/485	Switched Network Modem		3
D	**Communication Ports A & B**	RS-423/485	U.K. Modem	**Not FM**	4
		RS-423/485	Fiber Optic Modem	**Not FM**	5
		RS-423/485	MIB		6
		RS-423/485	RASCL (Redundant)	**Not FM**	7
		RS-423/485	RASCL (Single)	**Not FM**	8
		RS-423/485	RDI	**Not FM**	9
		RS-423/485	TIB	**Not FM**	A
		Port C	**Port D**		
		None	None		0
		RS-423/485	RS-423/485		1
		RS-423/485	Private Line Modem		2
		RS-423/485	Switched Network Modem		3
E	**Communication Ports C & D**	RS-423/485	U.K. Modem	**Not FM**	4
		RS-423/485	Fiber Optic Modem	**Not FM**	5
		RS-423/485	MIB		6
		RS-423/485	RASCL (Redundant)	**Not FM**	7
		RS-423/485	RASCL (Single)	**Not FM**	8
		RS-423/485	RDI	**Not FM**	9
		RS-423/485	TIB	**Not FM**	A
F G	**Not Used**	Enter 00 for these selections			0 0

ATTACHMENT 3330-B		
#1 #2 #3 #4 #5 #6	**I/O Module Selection**	Specify the I/O module code from the table on the following page to be installed in each of the first six I/O slots of the DPC 3330. Insert a 0 if no module is required in that slot.

ATTACHMENT 3330-C		
#7 #8 #9 #10 #11 #12	**I/O Module Selection**	Specify the I/O module code from the table on the following page to be installed in each of the second six I/O slots of the DPC 3330. Insert a 0 if no module is required in that slot. Use Attachment 3330-C only for a DPC 3330 with 12 I/O slots.

DPC 3330
DISTRIBUTED PROCESS CONTROLLER

SPECIFICATION SUMMARY

D456 SS-0d

Code	I/O Points	Description	
		ANALOG INPUT	
		Input Range	**Common Mode**
1	4	0-10 VDC	No
2	4	1-5 VDC/4-20 mA Note 3	No
3	4	0-10 VDC	Yes
4	4	1-5 VDC/4-20 mA Note 3	Yes
		LOW LEVEL ANALOG INPUT	**Note 2**
5	4	RTD TC J, K, T, R, S, B +/- 10 mV	**600 V C.M. Isolation** Yes
		ANALOG OUTPUT	
		Output Range	
6	2	0-10 VDC	
7	2	1-5 VDC/4-20 mA Note 4	
		DISCRETE INPUT	
		Input Range	**Filter**
A	8	24V AC/DC Note 3	1 mS
R	8	12V AC/DC Note 5	1 mS
B	8	12V AC/DC Note 5	30 mS
C	8	24V AC/DC Note 3	30 mS
D	4	120V AC/DC	30 mS
K	8	5V AC/DC	1mS
		DISCRETE OUTPUT	
		Output Type	
E	8	Open Collector	
F	4	Relay, +24V Coil Note 4	
M	4	Relay, +12V Coil Note 6	
		HIGH SPEED COUNTER	
G	4	+24 V Input Range Note 3	
H	4	+12 V Input Range Note 5	
N	4	+5 V Input Range	
P		**High Speed Analog Input Note 2** 4 AI (1-5 VDC/4-20 mA) 2DI (5V AC/DC)	
S	8	**Honeywell Smart Transmitter Interface Note 2** **Not FM Approved** Ref. Spec. Sum. D462SS-1 Replace 10 ft. cable with 30 ft. cable (PN: 391274-02-3)	
		CHECK BEFORE OPERATE Not FM Approved	
T	8	C.B.O. with Surge Protection	
U	8	C.B.O. with Fusing	
V	8	C.B.O. with External Relays	

Note 2: The LLAI, HSAI and HWSTI cannot be used in slots 1, 6, 7 or 12 in the 3330.
Note 3: 24 volt range I/O cards used with 12 volt internal power require an external 24 volt supply if power for contacts or transmitters is needed.
Note 4: Cannot be used with 12 V internal power.
Note 5: 12 volt range I/O cards used with 24 volt internal power require an external 12 volt supply if power for contacts or transmitters is needed.
Note 6: Cannot be used with 24 V internal power.

DPC 3330
DISTRIBUTED PROCESS CONTROLLER

SPECIFICATION SUMMARY

D456 SS-0d

	Base						Attachament - A							Attachachment - B					
	A	*B*	*C*	*D*	*E*	*F*	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*#1*	*#2*	*#3*	*#4*	*#5*	*#6*
Model Number: 3330-10A -	__	__	__	__	__	__	A __	__	__	__	__	__	__	B __	__	__	__	__	__

	Attachment - C						Attachment - D		
	#7	*#8*	*#9*	*#10*	*#11*	*#12*	*A*	*B*	*C*
- C	__	__	__	__	__	__	- D __	__	__

ATTACHMENT 3330-D			CODE
A B C	**Display/Keypad** *DO NOT include Attachment 3330-D in the Model Number if no Keypad is required.*	Built-in Keypad Remote Keypad	2 0 0 2 0 1
ATTACHMENT 3330-Z			
	Conformal Coating *DO NOT include Attachment 3330-Z in the Model Number if Conformal Coating is not required.*	**DPC 3330 with:** With 0 I/O Boards With 1 I/O Board With 2 I/O Boards With 3 I/O Boards With 4 I/O Boards With 5 I/O Boards With 6 I/O Boards With 7 I/O Boards With 8 I/O Boards With 9 I/O Boards With 10 I/O Boards With 11 I/O Boards With 12 I/O Boards	 Z-100 Z-101 Z-102 Z-103 Z-104 Z-105 Z-106 Z-107 Z-108 Z-109 Z-110 Z-111 Z-112
		With Built-in Keypad With Remote Keypad	Z-200 Z-201
	Fiber Optic Modem Rack	With Single Fiber Modem With Dual Fiber Modem	3330 - E100 3330 - E200

Note: The LLAI board is always conformal coated; therefore, DO NOT count it in the attachment.

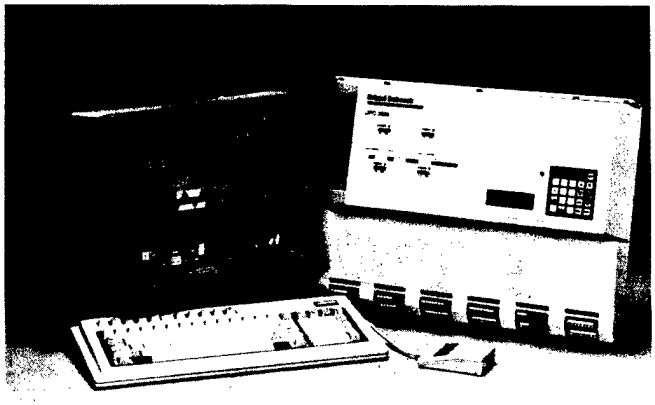
SPECIFICATION SUMMARY

D454 SS-2a

NETWORK 3000
GENESIS ™

FEATURES

- o Runs on 286- and 386-based computers
- o MS-DOS compatible
- o ICON-driven graphic display builder
- o Easy-to-use database builder
- o Comprehensive alarm reporting
- o Alarm, event, and report logging
- o Historic data archive and replay
- o Realtime and Historic trending
- o Lotus 1-2-3 compatible
- o On-line file transfer utility
- o Password protection
- o SPC/SQC
- o Networking software



GENERAL

Genesis is a powerful operator interface software package for Network 3000 products including DPC 3330, DPC 3335, RDC 3350, and UCS 3380 distributed process controllers, as well as Bristol Babcock's RTUs and single loop controllers. In process control, industrial automation and SCADA applications, Genesis provides data acquisition, operator graphics, trending, alarm logging, data logging, historical replay, report generation, and SPC/SQC functions.

Genesis was designed with both the operator and engineer in mind. It is the fastest to learn and easiest to use process operator interface software available. Genesis provides an icon-based, mouse-driven system for designing process graphics, and is completely CAD-based with object-oriented, AutoCAD compatible graphics, allowing timesaving import and export of process diagrams and displays.

Genesis provides outstanding flexibility by offering several levels of software packages to meet your system needs. In addition, its open architecture features make Genesis compatible with the needs of today's industry, including Lotus 1-2-3 and Microsoft "C" language. Moreover, Genesis supports realtime distributed networking capabilities that are NetBIOS compatible, supporting such LAN topologies as Ethernet, ARCNET, PCLAN, Token-Ring and Novell.

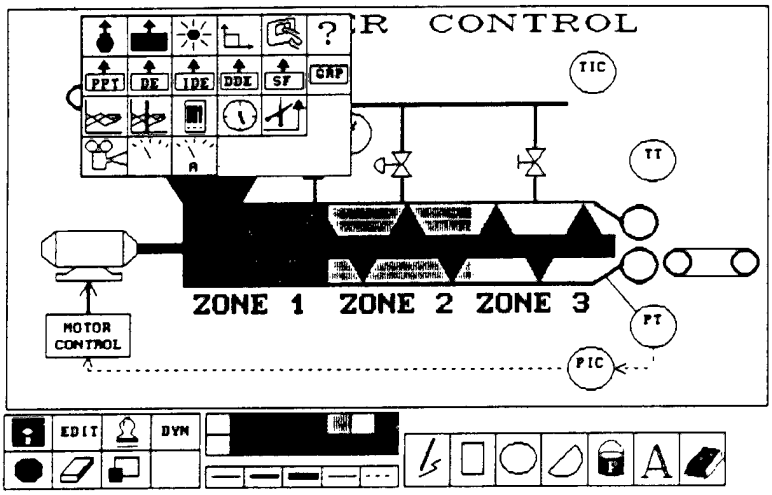
Genesis consists of two main parts: the *system configurator*, which runs under DOS; and the *runtime system*, which is a realtime, multitasking control system that is co-resident with DOS. The system configurator is a CAD-based system development environment which includes the *database builder* and the *graphics builder*. The runtime system executes the data collection system and provides a graphical operator interface.

DATABASE BUILDER

Probably the most outstanding feature of Genesis is its truly unique database builder. This utility extracts all flagged database signals from the ACCOL II program files and automatically generates an interface file for each Network 3000 process controller. Signals are then selected for inclusion into the database by simple selection with the click of the mouse. It's that easy. Also, using the mouse you can select from a library of acquisition, mathematical, logic, and calculation functions, position them on the screen, and connect them to database signals.

The realtime database can contain up to 120 Network 3000 process controllers and up to 6000 signals. The historic database can accommodate up to 800 signals. The self-documenting feature of Genesis provides the capability to produce a hard copy printout of the database.

Bristol Babcock



DISPLAY BUILDER

Creating Displays

The Genesis display builder is an advanced object-oriented, CAD-based tool for generating displays and reports specific to the application. Within the display builder, the user utilizes the mouse and convenient function icons to build complex displays quickly and easily. Unlike other pixel based systems, if you know how to sketch a line, box or circle, then you know how to use Genesis. You may draw and label basic shapes using a variety of drawing tools. To select a tool, you simply click on the appropriate icon. The tools include lines, bars, boxes, circles, ellipses, arcs, area fill, and text. The operation of the drawing tools can be modified with a selection of 16 colors, 3 line widths, 2 line styles, 2 text styles, and an unlimited number of text sizes.

Genesis has the most extensive graphics editing tools of any CAD-based process control software on the market. The editing functions of the display builder and strategy builder are nearly identical. These functions operate on actual objects, as opposed to pixels, to save time in building operator displays.

- The *move, resize* and *copy* functions operate on any selected display object, either static or dynamic, or any group of selected objects.
- The *attribute* function enables the user to change the color of an object previously created.
- The *cursor* function will display the X,Y coordinates of the mouse cursor while it is anywhere in the working screen area.
- The *rotate 90°* function rotates the selected symbol 90°.
- The *grids* and *gravity* functions allow precise positioning of the mouse cursor while it is anywhere in the working screen area. When *gravity* is enabled, all cursor movements are automatically snapped to the nearest grid intersection. The size of the grid may be easily altered to fit any display requirements. Both *grids* and *gravity* can be individually controlled.
- The *symbol generation* function, represented by the rubber stamp icon, allows the user to create complex symbols such as valves or motors, then store, recall, and reuse them as many times as desired. There is no limit to the number of symbol files which may be created. With the Genesis display builder, you never need to draw the same symbol twice. In addition, Genesis comes with a preconfigured set of ISA symbols.

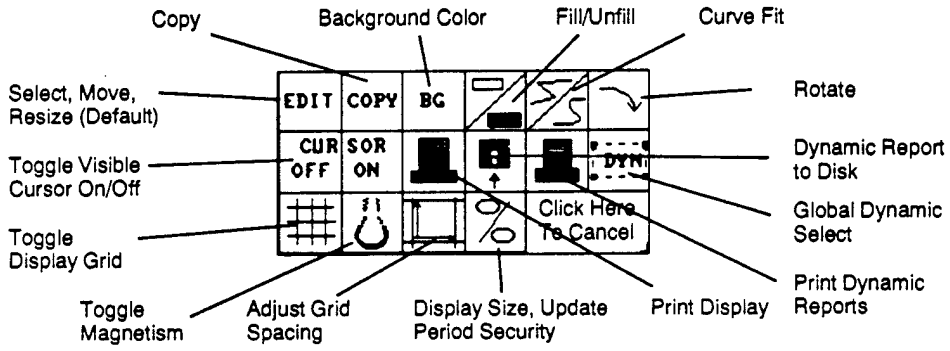
AutoCAD Support

Genesis provides users with the powerful option of importing any AutoCAD DXF compatible file into Genesis. These existing AutoCAD drawings may then be used as operator displays. Any strategy or display created within Genesis may also be exported to an AutoCAD DXF format for further manipulation and graphical editing within AutoCAD or any DXF compatible CAD tool.

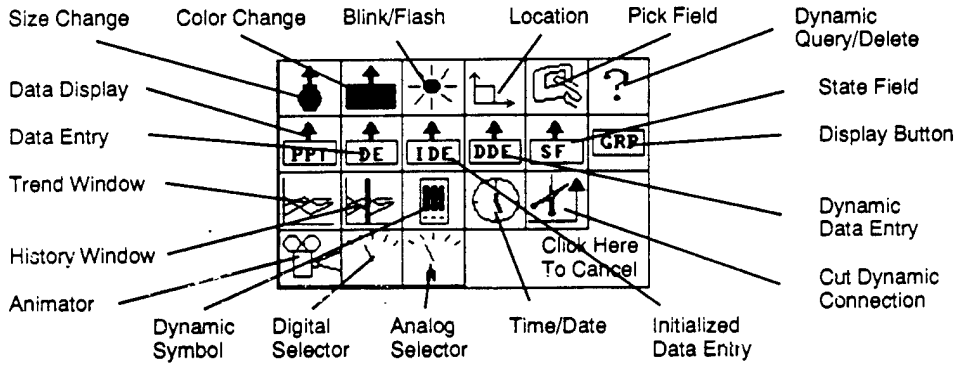
Dynamic Connections

An important feature of the display builder is its ability to graphically display any process variable within the database. A wide range of dynamic connection functions enables the user to graphically or verbally depict exactly what is going on in the process.

- *Dynamic shape* - Bars, boxes, circles, and ellipses connected with the dynamic shape function will grow and shrink in proportion to the value of the process variable. Six different modes of operation, including bar graphs and bias bars, are possible with connections to boxes and bars.
- *Dynamic symbols* - Users may define complex symbols that contain many dynamic connections and save them as a single component. This function saves a tremendous amount of time in that complex symbols which require a great deal of time and care to create can be used in different places, numerous times, without having to redefine each dynamic connection each time the entire component is used.



Display Builder EDIT Submenu



Dynamic Connection Submenu

- *Dynamic color* - Any object can have up to 8 different colors based upon the state of digital process variables. Any of the 16 available colors may be used.

- *Data entry* - Process variables may be modified by the operator through numeric Data Entry fields. Initialized Data Entries can be used to construct recipe pages. Also, upper and lower Data Entry limits as well as 4 levels of security may be selected. Dynamic data entry points provide read and write capability in the same field.

- *State fields* - This function allows users to customize messages within the display builder. State fields can operate in three modes: (1) display, where the text represents the value of a process variable; (2) data entry, where the operator scrolls through user-defined text states and then downloads their associated analog or digital values to the process; and (3) data entry and display, a combination of the two.

- *Pick fields* - Any object in a display may be defined to execute any single operator interface command or a macro that exists in the current key macro library. Once defined, the pick field can be selected from the display during runtime and have its corresponding command or macro executed. A pick field may be selected through the keyboard, mouse, or touch screen.

- *Process point* - Any process value, including both dynamic variables and descriptive text, can be displayed at runtime. Process point formats can be user selected and scientific notation is available.

- *Trend window* - Trend windows, graphically showing the change in variables over a period of time, can be incorporated into operator displays. There can be as many as 8 pens per trend window, each representing a variable with a different color, and there is no limit to the number of trend windows per display. Trend times can be set

anywhere in the range of 30 seconds to 48 hours. Trend windows have no prior history before the display is in view. Once the display is in view, they become scroll windows.

- *X-Y displacement* - Graphic animation of an object is possible with X-Y displacement. Objects may be connected to separate variables on the X and Y axes.

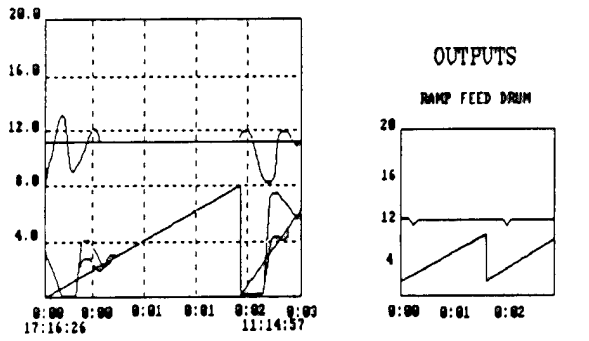
- *Blink* -Any object can be caused to blink when connected to a digital process variable.

- *Analog-digital selectors* - Objects within a group may be selected for display based on an analog value or digital status of the connected variable.

- *Time* -The PC system time and/or date may be displayed on any graphic screen in a number of various formats.

- *History windows* - Similar to trend windows, history windows may appear in operator displays to show live and historic trend data from open history files. History windows can be configured for up to 20 pens or variables, each with its own color. The x-axis can be a time scale or one of the process variables. The grid lines can be linear or logarithmic.

History Windows



HISTORY FILE : HIST1

REL. TIME	X	Y 1	Y 2	Y 3	Y 4	Y 5	LOGARITHM N
MIN 000:00	00000.0	0000.00	0000.00	0000.00	-15.00	-15.00	X GRIDS 04
MAX 000:03	00000.8	20.00	20.00	20.00	15.00	15.00	Y GRIDS 04

- *Display animation* - This function provides the ability to animate selected objects based upon the levels of an analog signal or the state of a discrete event. The animation icon allows you to select a group of graphic objects that will be sequenced when a defined digital state goes true. This function is like having a movie projector and a set of pictures to show when the switch is ON.

- *Dynamic report* - A convenient report that defines all of the dynamic connections for a given display can be generated from within the Genesis display builder and sent to either the configured printer or an ASCII disk file. The dynamic report clearly outlines all of the actual links and connections for the current display.

Display Hierarchy and Key Macro Assignments

Genesis provides a powerful and flexible means of creating display hierarchies of unlimited size. Each display has the capability of redefining all of the function keys and assigning them to bring up any display in the system. Function keys may also be defined to call up any system level function such as turning signals on or off, acknowledging alarms, etc. A sequence of key actions may be grouped into a "named macro" and assigned to any key on the keyboard, touch screen, pick field, or mouse button.

RUNTIME SYSTEM

The runtime system provides realtime and historical data acquisition for color graphic display, trending, and reporting functions. Data entry fields allow setpoint changes, on-off status changes, and manual override of signal values. The Genesis runtime system provides a very powerful operator interface; yet it is still very easy for operators to use.

Scan on Demand

In order to maximize communication and data throughput Genesis runtime employs a scan on demand technique whereby only data for the current viewable display and historical collection are scanned. Also, individual signals can be set to *continuous scan, forced to scan for reports*, and *scanned as required* when connected into or out of a device block. Unnecessary data are not scanned.

Operator Displays

Genesis operator displays can be accessed in several different ways. First, displays may be selected from a directory of all displays in the system. The operator can view and page through the directory using function keys defined by the system engineer. Also, custom display menus may be created with *display buttons* feature. Defined in the display builder, display buttons enable the operator to tab or click over the button corresponding to the desired display. Finally, an operator function keyboard can be used and customized to the application.

Remote Signal Access

Genesis allows an operator to access any database signal that is displayed on a graphic screen. Database variables that are not displayed on a screen can be easily accessed from the *tag*

sort page. A unique feature of Genesis also allows access to any ACCOL signal in any node in the network, even if it is not in the Genesis database. By simply typing in the node and signal name in the subwindow, the operator reads the signal and can change its value or control, manual and alarm inhibit status.

Datalogging

The Genesis *event driven historian* produces ASCII files designed to be directly imported by Lotus1-2-3. These files can also be printed, displayed, stored to disk, or transferred on-line to a network file server.

The event driven historian is a flexible datalogging mechanism that allows datalogging to be started and stopped based on process conditions and events or by operator request. Data can be logged to as many as 40 different files, while up to 20 points can be logged to each file for a total of 800 tags. The logging rate for each file can be switched between two rates or selected external signal. This feature allows you to increase the logging rate and the number of collected samples during process upsets.

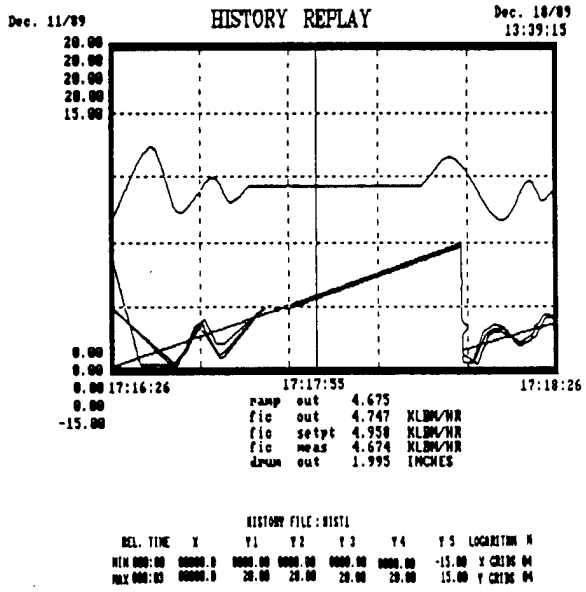
Online Historical Replay

The *historical replay* is an on-line function allowing the operator to review historical files created by the event historian. Files can be replayed in a tabular or graphical format. The historical replay also allows you to compress or expand the time window and provides the ability to change the limits on any given variable. During historical replay, the system maintains full operation, including datalogging and short-term trending.

The *tabular replay* is a spreadsheet type display allowing simultaneous viewing of up to 8 variables. You may scroll up and down through the file in groups of 18 records and scroll left to right in groups of 4 or 8 variables.

The *graphical replay* displays a trend style graph of up to 5 variables at a time. From the keyboard, you can page quickly between all variables in the file. A record detail cursor can be moved across the graph to display the time and value of each sample in the file.

History windows may appear in operator displays to show live and historical trend data from open history files. History windows can be configured for up to 20 pens or variables simultaneously, each with its own color. They can also contain user-defined time scale (X and Y axes) resolutions as well as a logarithmic scale.



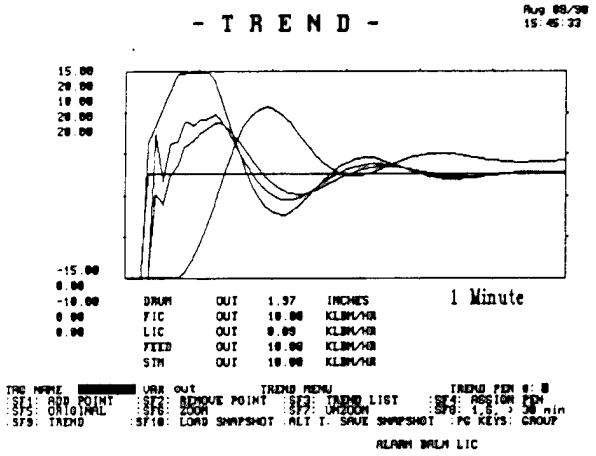
Realtime Trending

In addition to the trend windows and history windows that can be integrated into any display, Genesis offers a *system trending* function which can be configured during runtime or pre-configured during application development. The system trending function collects data in memory for up to 20 variables simultaneously. Once this data is collected, you may then graphically display the data in realtime groups of five variables at a time. System trending is very useful for monitoring critical process variables or control loop tuning.

System trending is a system-built function with a dedicated display providing an external data storage buffer storing up to 60 samples of 20 variables in 3 system buffers. Any 5 of these variables may be displayed simultaneously. The *plot* function provides an alternative display format for the system trending function, allowing you to plot 4 variables on the Y-axis against 1 variable on the X-axis. System Trending also provides a trend "snapshot" capability allowing the operator to instantly capture trend curves for later replay. Up to 40 "snapshots" may be stored simultaneously. Another feature, *data zoom*, enables you to expand the view of any one of the traces in the trend window while automatically re-computing the scale.

Trend windows are an integral part of the operator graphics display. Unlike system trending, which constitutes a separate display, trend windows are part of a display for a given

process. These windows provide the operator with a higher level of correlation between the trended data and the rest of the process. Each trend window displays up to 8 variables. The trend window time frame is also user-defined, ranging from 0.5 minutes to 48 hours.

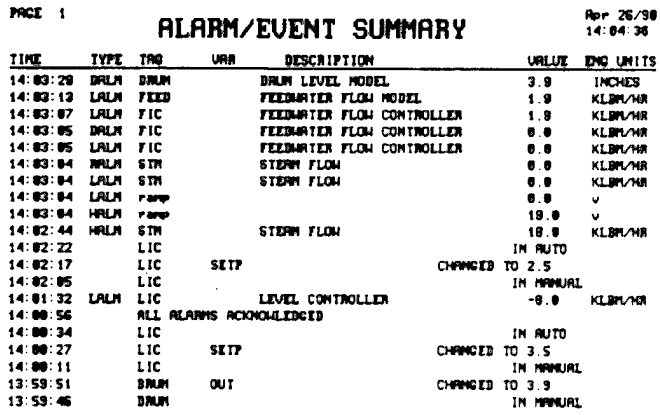


Alarm System

Network 3000 distributed process controllers provide a unique alarm system whereby alarms are detected and time stamped in the process controller at the time of occurrence and transmitted to Genesis.

Time-stamped state and change-of-state alarms for logical signals and high, high-high, low, low-low, deviation, and rate-of-change alarms for analog (numeric) signals can be reported. Alarm reports are logged in an alarm history, which is displayed on the CRT and can be logged to a printer and/or disk file. Operator events, i.e. setpoint changes, can also be logged in the same manner. The alarm summary is a display of the last 20 alarm/event entries per page. Up to 35 pages or 700 entries may be configured.

Alarms in the *alarm summary* are color coded. Unacknowledged alarms are displayed in red, acknowledged alarms in yellow, and unacknowledged alarms no longer in an alarm state in green. You may set the alarm summary to log all points entering or exiting alarm conditions to the screen, a printer, to disk or any combination of the three. Genesis also provides an alarm squelch and priority mechanism which may be set to suppress non-critical alarms. Alarm returns and acknowledgement colors may be custom configured.



Key Macros

A convenient and helpful feature of the Genesis runtime system is the ability to reassign runtime keyboard functions to correspond to your exact needs. Any keyboard can have individual keys, key combinations, or entire batch macros defined on a per-strategy and per-display basis. Through *key macros*, you may set an entire sequence of operator commands to be executed by a single keystroke, click of a mouse, or touch of a screen. Key macros further optimize your operator interface, making the operator's job easier and more efficient.

Mouse Driven Runtime

Genesis provides mouse support for operator displays. Any Logitech, Microsoft, or Mouse Systems compatible mouse or trackball may be used on a process point, data entry, pick field, key macro, or subwindow field within a display. This feature adds flexibility and ease of use for operators.

Additional Features

System Time/Date

DOS level time and date settings may be set from within the runtime system and sent to the Network 3000 controllers. This time sync message is sent on startup, on demand, and every midnight.

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SPECIFICATION SUMMARY D454 SS-2a

GENESIS OPTIONAL PACKAGES

Report Generator

The Genesis *report generator* option provides an easy-to-use configurator, in the form of a spreadsheet, to produce free format scheduled and demand reports.

The report function provides the ability to automatically collect selective data simultaneously from an active process, multiple history files, alarm logs, or even from other nodes on a Genesis network. A complete library of mathematical, statistical, and boolean function are also provided, and allow you to perform any necessary calculations and manipulation of process data. All resultant outputs from the report function can be directed to either a configured printer or a disk file.

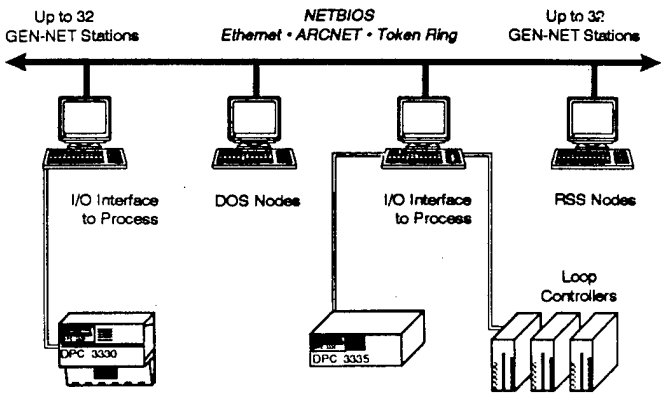
Text can be integrated anywhere in a report to relate the contents of the report data to the reader. Text fields that display different text messages based upon system states and/or events can also be placed discretionally into a report, and, like constant text, they can be merged with both alarm and operator event log data. Operator message fields can also be configured to provide the addition of Runtime notes and comments to any report.

Genesis Networking (GEN-NET)

GEN-NET is an advanced networking option for Genesis. GEN-NET provides both realtime access to live data and file transfer.

Fully NetBIOS and Novell compatible, GEN-NET allows realtime data, file, and alarm messages to be passed between all Genesis nodes. Running either Ethernet, direct ARCNET topologies, Token-Ring, or Novel LAN topologies, each Genesis node can operate independently, allowing you to distribute the system functions and process loading of a stand-alone Genesis system amongst all of the Genesis workstations in the network. GEN-NET's independent operation provides all nodes instant access to the network without being delayed by a centralized file server and ensures that the failure of any one node does not hinder the operation of others.

GEN-NET nodes can be integrated and reconfigured quickly into any process by clicking on the NODE icon and dragging it into the database strategy window. The GEN-NET nodes are then graphically configured to your exact process specifications by simple configuration menus. For remote applications, serial GEN-NET provides asynchronous network communications with modems, short haul modems, or direct cable connect through a communication port.



Remote Supervisory Station (RSS)

The *remote supervisory station kit (RSS-KIT)* is a networking product providing access to a "master" Genesis system by one or more remote stations. RSS-KIT is made up to two products: *RSS-Remote* and *RSS-Master*. RSS-Remote, a special runtime version of Genesis, allows remote stations to function as full operator workstations providing process monitoring and supervisory control through access to live data, operator graphics, trend charts, and historical files. Furthermore, each of the remote stations has the ability to modify setpoints and select and modify operating parameters.

RSS-Master, similar to the networking option GEN-NET, utilizes popular networks, such as Ethernet, ARCNET, Token-Ring, and other NetBIOS compatible topologies to establish communications between remote stations and the master station. Modem communication is also available. RSS-Master provides network support for up to 32 remote stations connected to a single Genesis master station. The master station executes the user's database strategy, providing the first level of interface to the process. It also functions as a master database for the RSS Network. The remote stations request realtime database information from the master station while periodically receiving new process data for display purposes. For instance, when display, trend, or historian operations are executed on a remote station, requests are sent to the master station. The master station then responds by sending current information at rates as fast as 0.1 second. Likewise, if new information, such as setpoints, is entered at a remote station, the values are sent to the master station automatically. The master station then downloads these values to the Network 3000 controllers.

NETWORK 3000
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SPECIFICATION SUMMARY

D454 SS-2a

The remote supervisory station always keeps you close to your process. RSS allows process and plant engineers to interact with the process from several locations throughout the plant, utilizing the same mechanisms and displays provided on the master station. Regardless of whether you are in the office, the control room, on the factory floor, or even at home, RSS can provide you with constant access to your process.

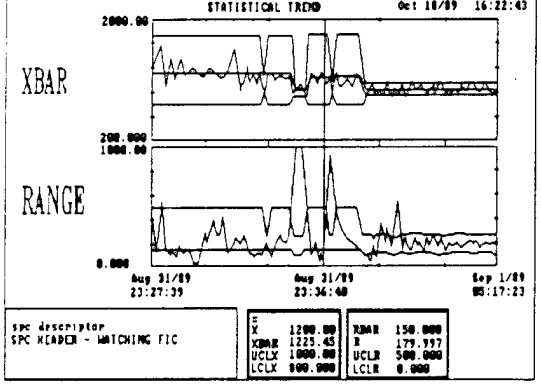
Statistical Process Control & Statistical Quality Control

With the increasing importance of statistical information to ensure product quality and accuracy while maintaining process productivity, the *Genesis SPC/SQC function*, GEN-SPC, provides on-line statistical process and quality control that allows the integration of statistical data collection with quality control into laboratory and production control strategies. GEN-SPC provides the ability to automatically collect sampled data, calculate the quality control parameters, and log the data to disk. Additional on-line features allows you to selectively view and set process parameters, implement X-bar/R Shewhart charts, and set alarms that will automatically alert operators to any out of specification conditions.

As with other Genesis functions, the icon-based SPC function is implemented into the process strategy by clicking on the SPC icon and dragging it into the control strategy. GEN-SPC is then configured to your exact process specifications by connecting existing database variables into the SPC block. SPC outputs can be connected to any process controller to perform closed loop statistical control.

The SPC function collects samples and calculates group averages. Each time a complete group is collected, statistical data about the group is calculated. The number of samples within a group, the period between samples, and the sampling of the next group can all be set via SPC/SQC parameters.

The SPC function can simultaneously replay historical data while plotting current statistical data. Data is plotted in a Shewhart chart format with the capability of toggling the plot display based upon range variables or standard deviation variables. The SPC function supports three modes of operation: periodic data sampling, event sampling and manual data entry.



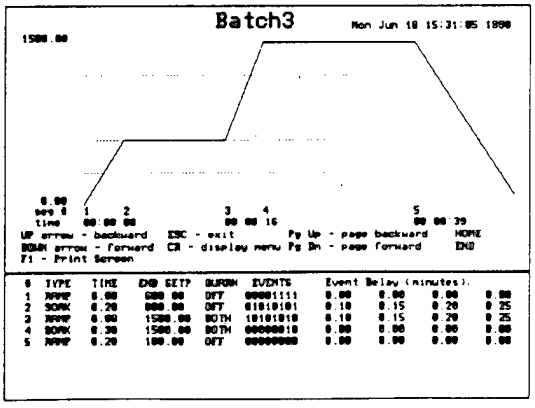
Setpoint Profiler (GEN-SETPT)

The *setpoint profiler* is a Genesis function that provides ramp, soak, and step profile operations to loop controllers or Network 3000 distributed process controllers. Setpoint profiler allows you to create unlimited profiles, each operating independently or synchronized with other profiles. Setpoint profiler is ideal for a variety of processes requiring setpoints to be ramped up or down, held constant, or varied according to a step function.

The user can generate a large number of complex profiles with the easy-to-use Genesis *profile builder*. These profiles can be prototyped graphically and replayed prior to their final implementation. Possible applications for the setpoint profiler include heat treating, plastics, chemicals, and other batch oriented operations.

The primary function of the setpoint profiler algorithm is to generate a setpoint value which is changing in time and then to transmit that value to the setpoint of a process controller. The setpoint profiler algorithm is comprised of various segments. The algorithm receives an initial setpoint parameter which is either varied or held constant by each of these segments. The user selects and orders different types of segments to achieve a desired result.

The setpoint profiler offers four types of segments: RAMP, SOAK, STEP, and LOOP. RAMP is used to linearly increment or decrement the input setpoint. The user configures the RAMP segment by specifying the final setpoint and the duration of the RAMP. SOAK simply holds a setpoint constant for the duration of the segment. STEP will instantly change the setpoint to some other desired value. LOOP will repeat a specified number of segments.



NETWORK 3000
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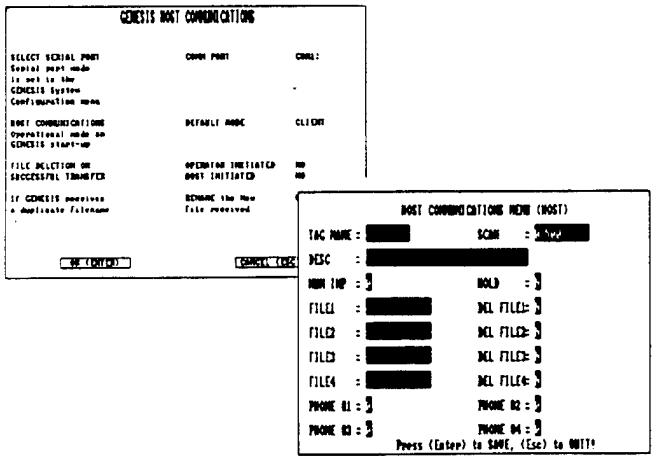
SPECIFICATION SUMMARY D454 SS-2a

Host Communications (GEN-HOST)

To accommodate the expanding variety of host computers being used in the process control industry, Genesis offers the capability to easily link its data acquisition software to these host computers. By integrating the *host communications option* (GEN-HOST) into the Genesis software, single point-to-point, on-line file transfer can be performed. Host communications are executed using standard RS-232C and RS-422 between a Genesis system and any host computer running the KERMIT communications protocol.

File transfers may be performed even while Genesis is executing other tasks. HOST makes it possible for the Genesis and host systems to automatically send or receive any ASCII or binary files in the runtime environment. File transfers can occur based upon discrete events (i.e. alarms), scheduled times (i.e. hourly, daily, weekly, etc.) or by direct operator action. Additionally, files that are transferred via GEN-HOST do not need to be closed prior to their transmission. This feature allows open files, such as historical data files and SPC files, to be transferred while data is actively being written to them.



Modem Interface (GEN-MODEM)

The Genesis *modem function* is a complimentary option to the GEN-HOST communications option. GEN-MODEM provides full Hayes B compatible modem support for HOST computer capabilities such as realtime file transfer. With GEN-MODEM, the user has the option of transferring files or data based on time, event or manual command.

With GEN-MODEM, an operator can dial in to a Network 3000 process controller and have remote access to system-wide information.

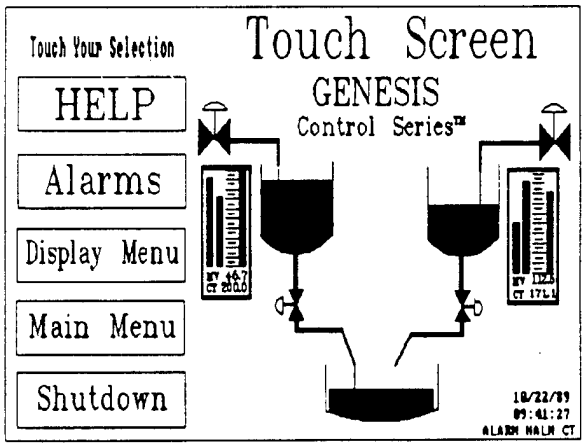
The Genesis modem function supports auto-dial and auto-answer access to any Genesis system from a Hayes B compatible external or internal PC-based modem. GEN-MODEM currently supports several useful and flexible modes of operation involving both manual and automatic operation.

Touch Screen Interface (GEN-Touch)

The *touch screen operator interface option* makes the Genesis Control Series even faster and easier to use. With the touch screen interface, operators can interact easily with any process by simply touching the screen! The touch screen interface allows you to create multiple screen menus and displays that are linked together by single one-touch operations. Any user defined graphical object, from simple boxed text to complex pumps, motors and valves, can be defined as "touchable" within any Genesis display. The integration of the touch screen interface option and the appropriate touch screen hardware will propel your data acquisition and process control applications into the forefront of efficient operator interaction.

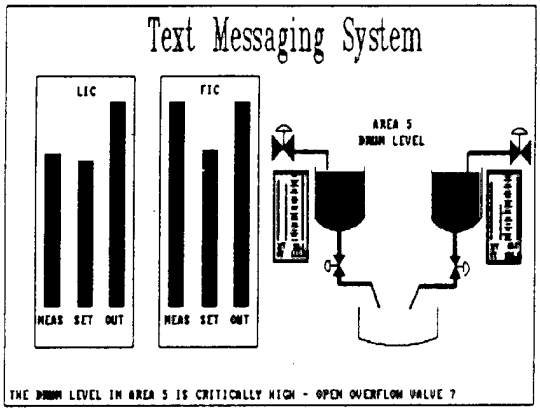
The touch screen option lends itself to direct use with the standard Genesis pick field and key macro functions. The pick field function allows any object in a Genesis display to be selectable during runtime with either the TAB key, a mouse, or by touching it. Once an object has been defined as selectable, the key macro function will perform any of over 70 individual key macro commands, or it can be defined to perform multiple command operations from a macro file.

Setting up the touch screen interface for use with Genesis is done easily and quickly. Genesis currently supports Micro-Touch Systems' capacitive technology, Elographics' Intellitouch sonar acoustic wave, and Carroll Touch's Smart-Frame infrared touch screen systems. This touch screen hardware can be installed easily and quickly, and requires an available serial communications port.



Text Messaging System (GEN-Text)

Genesis makes it possible for customized text messages to be defined and sent to any peripheral device. The *text messaging option* allows you to predefine the exact content of up to 4096 different ASCII messages and route them to any device, the Genesis runtime display line, or to the event log.



These messages can be used to relate, in detail, various process occurrences such as: the status of a particular operation; the condition of an event; the prompting or instructing of the operator to perform a specific procedure; notification of the proper personnel of an emergency situation; or any other process occurrence that would require a unique message to be directed to the appropriate location.

GEN-Text allows ASCII text messages to be sent to a variety of peripheral devices such as: overhead display systems, printers, pagers, modems, the system screen, or any other device that can be connected to one of the four serial ports or three parallel ports. No longer will your operators be burdened with the task of trying to interpret how the generic system messages that are displayed on the screen or printer relate to their particular process event.

"C" Users Development Kit (GEN-USER)

The Genesis *"C" user development kit*, or *user task*, is a comprehensive package providing you with the power and flexibility of creating and implementing custom applications written in standard Microsoft "C" language. User task allows you to create special functions which complement the overall functionality of the system. The package includes a variety of functions supporting access to the realtime database, serial and parallel ports, and historical and statistical data files, The "C" user task is ideal for operations such as custom calculations, interfaces to other computers, special cases of recipes and reports, and special file oriented functions.

The open architecture feature of Genesis allows user-defined functions to be efficiently implemented as part of the Genesis system. The user task provides the highest level of user interaction within the Genesis system, taking full advantage of the open architecture feature. User task allows you to create a totally independent task to run in the Genesis runtime multitasking environment. A specific user task may include special calculations, access to disk drives or files, optimization routines, or file format conversion. With user task, you can define a task that becomes an interactive part of the surrounding system will full access to all current data, file based information, history files, ports, keyboard, as well as user-created databases. The "C" user task places complete control in your hands!

HARDWARE REQUIREMENTS

Due to the large number of personal computer and add-on manufacturers, it is impossible to test every PC and every combination. Genesis has proved to operate satisfactorily on most PC platforms. Bristol Babcock recommends a Compaq 386 with 2 MB RAM for most systems. A 286-based PC can be used for smaller systems of less than 400 signals. Memory expansion cards such as the Intel Aboveboard and Boca Research's BocaRAM are generally compatible with most PCs, but there are no guarantees. For this reason, Bristol Babcock recommends the following system:

- Compaq DeskPro 386
- 2 MB memory
- 20 MB fixed disk minimum
- 1.2 MB floppy disk
- Math coprocessor
- VGA card
- VGA color monitor
- 1 serial port (2 ports preferred)
- 1 parallel port (2 ports preferred)
- Mouse (3 button Logitech serial mouse recommended) required for configuration only
- QEMM 386 memory software

Known Incompatible Systems

- o HP Vectra, old models
- o AT&T 6300
- o Swan Computer
- o Prolog PC/2 STD card
- o Ziatech Z1000
- o NEC new models (serial ports are not Genesis compatible; will work if different COM cards are installed)

Optional Hardware

- o Graphics printer: Okidata or Epson parallel printer
- o Color graphics printer: Hewlett Packard PaintJet
- o Operator keyboard: Floorboard membrane keyboard
- o Up to 3 parallel ports
- o Up to 4 serial ports
- o ARCNET card
- o Touch screen
- o Trackball

SPECIFICATIONS

Capacity

- o I/O points: 6000 signals
- o Number of nodes: 120
- o Number of communication ports supported: 4
- o Number of parallel ports supported: 3

Performance

- o I/O point scan rate: .5 second maximum
- o Serial communication speed: up to 19.2K baud
- o Display update: .5 second
- o Display access: 1-4 seconds typically

Displays

- o Number of displays: limited by disk size only
- o Display size: 1-64 KB
- o Dynamic connections per display: 256 total
- o Display data types:
  - Process points
  - Data entry points
  - Initialized data entry
  - Numerical analog
  - Bar graph
  - Trend window (realtime and historical)
  - Logical on/off color change
  - Logical on/off text
  - Blink
  - Message
  - Data entry point
  - Dynamic data entry
  - State field
  - Subwindow
- o Password security levels: 4

Event Driven Historian

- o Number of variables: 800
- o Number of open files: 40
- o Number of variables per file: 20
- o Sample rates (per file): 0.1, 0.25, 0.5, 1, 2, 6, 12, 30 seconds
- o Sample rate selection: externally configurable
- o File size: configurable
- o File structure: Lotus compatible .PRN format

Trending

- o Realtime trend window
  - Number per page: no limit
  - Pens per trend window: 8
  - Update rate: >=0.25 seconds
  - Window time span: 30 seconds to 48 hours
  - Number of samples per window: variable
- o History trend window
  - Number per page: 4
  - Pens per trend window: 20
  - Window time span: 1 minute to 99 hours
  - Number of samples per window: variable
- o System trending
  - Number of variables: 20
  - Number of pens: 5 per window
  - Time span: 1 minute to 48 hours
  - Update rate: 1 second
  - Number of trend snapshots: 40
- o Historical replay trends
  - Number of variables: 20 per file
  - Number of pens: 5 per window
  - Time scaling: configurable
  - Vertical scaling: configurable

Appendix H - LCCID Output Files

Life Cycle Cost Study, Full Fuel Savings, 15 years, $3000/year maintenance

LIFE CYCLE COST ANALYSIS SUMMARY — STUDY: IAAP
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) — LCCID 1.080
INSTALLATION & LOCATION: IOWA ARMY AMMUREGION NOS. 7 CENSUS: 2
PROJECT NO. & TITLE: W54 FEASIBILTY STUDY FOR SDCS AT IAAP
FISCAL YEAR 1994 DISCRETE PORTION NAME: STEAM DISPATCHING
ANALYSIS DATE: 08-04-94 ECONOMIC LIFE 15 YEARS PREPARED BY: CHRIS DILKS

1. INVESTMENT

A. CONSTRUCTION COST	$ 213271.		
B. SIOH	$ 12000.		
C. DESIGN COST	$ 25000.		
D. TOTAL COST (1A+1B+1C)	$ 250271.		
E. SALVAGE VALUE OF EXISTING EQUIPMENT	$ 0.		
F. PUBLIC UTILITY COMPANY REBATE	$ 0.		
G. TOTAL INVESTMENT (1D - 1E - 1F)		$	250271.

2. ENERGY SAVINGS (+) / COST (-)
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1993

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ .00	0.	$ 0.	11.93	$ 0.
B. DIST	$ .00	0.	$ 0.	13.49	$ 0.
C. RESID	$ .00	0.	$ 0.	14.96	$ 0.
D. NAT G	$ 3.50	7114.	$ 24899.	14.53	$ 361782.
E. COAL	$ 1.39	21223.	$ 29500.	13.00	$ 383500.
F. LPG	$ .00	0.	$ 0.	12.78	$ 0.
M. DEMAND SAVINGS			$ 0.	11.85	$ 0.
N. TOTAL		28337.	$ 54399.		$ 745282.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		$ -3000.
(1) DISCOUNT FACTOR (TABLE A)	11.85	
(2) DISCOUNTED SAVING/COST (3A X 3A1)		$ -35550.

B. NON RECURRING SAVINGS(+) / COSTS(-)

ITEM	SAVINGS(+) COST(-) (1)	YR OC (2)	DISCNT FACTR (3)	DISCOUNTED SAVINGS(+)/ COST(-)(4)
d. TOTAL	$ 0.			0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-)(3A2+3Bd4) $ -35550.

4. FIRST YEAR DOLLAR SAVINGS 2N3+3A+(3Bd1/(YRS ECONOMIC LIFE)) $ 51399.

5. SIMPLE PAYBACK PERIOD (1G/4) 4.87 YEARS

6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) $ 709732.

7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)= 2.84
(IF < 1 PROJECT DOES NOT QUALIFY)

8. ADJUSTED INTERNAL RATE OF RETURN (AIRR): 10.52 %

Life Cycle Cost Study, Half Fuel Savings, 15 years, $3000/year maintenance

LIFE CYCLE COST ANALYSIS SUMMARY — STUDY: IAAP1
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) — LCCID 1.080
INSTALLATION & LOCATION: IOWA ARMY AMMUREGION NOS. 7 CENSUS: 2
PROJECT NO. & TITLE: W54 FEASIBILTY STUDY FOR SDCS AT IAAP
FISCAL YEAR 1994 DISCRETE PORTION NAME: STEAM DISPATCHING
ANALYSIS DATE: 08-04-94 ECONOMIC LIFE 15 YEARS PREPARED BY: CHRIS DILKS

1. INVESTMENT

A. CONSTRUCTION COST	$ 213271.		
B. SIOH	$ 12000.		
C. DESIGN COST	$ 25000.		
D. TOTAL COST (1A+1B+1C)	$ 250271.		
E. SALVAGE VALUE OF EXISTING EQUIPMENT		$ 0.	
F. PUBLIC UTILITY COMPANY REBATE		$ 0.	
G. TOTAL INVESTMENT (1D - 1E - 1F)			$ 250271.

2. ENERGY SAVINGS (+) / COST (-)
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1993

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ .00	0.	$ 0.	11.93	$ 0.
B. DIST	$ .00	0.	$ 0.	13.49	$ 0.
C. RESID	$ .00	0.	$ 0.	14.96	$ 0.
D. NAT G	$ 3.50	3557.	$ 12450.	14.53	$ 180891.
E. COAL	$ 1.39	10612.	$ 14750.	13.00	$ 191750.
F. LPG	$ .00	0.	$ 0.	12.78	$ 0.
M. DEMAND SAVINGS			$ 0.	11.85	$ 0.
N. TOTAL		14169.	$ 27199.		$ 372641.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-)		$ -3000.
(1) DISCOUNT FACTOR (TABLE A)	11.85	
(2) DISCOUNTED SAVING/COST (3A X 3A1)		$ -35550.

B. NON RECURRING SAVINGS(+) / COSTS(-)

ITEM	SAVINGS(+) COST(-) (1)	YR OC (2)	DISCNT FACTR (3)	DISCOUNTED SAVINGS(+)/ COST(-)(4)
d. TOTAL	$ 0.			0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-)(3A2+3Bd4)	$ -35550.
4. FIRST YEAR DOLLAR SAVINGS 2N3+3A+(3Bd1/(YRS ECONOMIC LIFE))	$ 24199.
5. SIMPLE PAYBACK PERIOD (1G/4)	10.34 YEARS
6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C)	$ 337091.
7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)= (IF < 1 PROJECT DOES NOT QUALIFY)	1.35
8. ADJUSTED INTERNAL RATE OF RETURN (AIRR):	5.17 %