NAVAL FACILITIES ENGINEERING SERVICE CENTER
Port Hueneme, California 93043-4370

# Technical Report
## TR-2091-ENV

# CLEANING OF LIVEFRONT ELECTRICAL SWITCHGEAR USING CARBON DIOXIDE PELLETS AT NAVY INSTALLATIONS

by

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CLEANING OF LIVEFRONT ELECTRICAL SWITCHGEAR USING CARBON DIOXIDE PELLETS AT NAVY INSTALLATIONS

Equipment procured under:
Contract # N63387-97-RC-4006
Navy Public Works Center
2730 Mckean ST.
San Diego, CA. 92132
issued to:
Alpheus Cleaning Technologies
9119 Milliken AVE.
Rancho Cucamonga, CA. 91730
dated
May 14, 1997

## ACKNOWLEDGEMENTS

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# EXECUTIVE SUMMARY

Navy Public Works personnel are required to periodically clean large electrical switchgears known as Load Interrupter (LI) switches as a preventative maintenance practice to prevent dielectric breakdown and arcing that would result in expensive equipment damage and power outages. For example, PWC San Diego needs to clean 740 high voltage switches every two years. The current practice is to de-energize the equipment and manually wipe surfaces with rags, sometimes using a synthetic oil, grease, or a chlorinated solvent which contributes to environmental problems. The cleaning must be performed at night or on weekends in order to avoid downtime to customers.

The purpose of this project was to evaluate a technique that uses carbon dioxide ($CO_2$) pellets, which have a dielectric constant equal to air, to clean energized electrical switches eliminating solvent usage, scheduled power outages, and overtime labor rates. Demonstration testing was required to enable Navy-wide implementation of this process. Objectives of the test program were verification of cleaning effectiveness, development of safe work practices, and evaluation of potential impacts on electrical switchgear. The project was conducted jointly with PWC San Diego and leveraged about \$125K of PWC funds to procure a $CO_2$ cleaning system.

The safe work practices were developed through the Standard Operating Procedure which is discussed in detail in Sections 4.0, 5.0, and Appendix D. A series of ten tests were conducted at the San Diego Naval base on 15kV energized switches. The test results show that the $CO_2$ cleaning process is a method that can be safely used to clean energized LI switchgear, performs in an efficient manner, and does not cause any damage to the component parts. Furthermore, the $CO_2$ process is environmentally friendly and improves system reliability and customer service by reducing station power outages.

The cost benefits of the $CO_2$ process are those that will be realized by having a regularly scheduled switch cleaning program, being conducted at the schedule of PWC, and avoiding power outages and their crises responses. The use of regularly scheduled preventive maintenance is a cost savings that will vary at each Navy activity.

Using a conservative estimate of savings of 1.5 man-hours per switch cleaned, and one power outage avoided per year, the yearly savings would be \$40K/yr. A simple pay back of the \$125K capital cost of the equipment is about 3 years. A shorter pay back of 1.2 - 2.2 years could be attained if higher labor savings are obtained as discussed in Section 6.3.2. Savings could be even greater if more power outages or other higher power outage costs are considered.

It is recommended that Navy activities consider the use of this technology to improve the methods currently used in cleaning Livefront LI electrical switchgear.

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# 1.0 INTRODUCTION

## 1.1 OBJECTIVE

The Objective of this project is to evaluate a promising technique that uses carbon dioxide ($CO_2$) pellet media blasting to clean energized power distribution equipment. This process has been in use in industry for some time to clean various kinds of equipment, but its use in high voltage applications has had limited evaluation. The objective is to demonstrate the process on energized ( ~ 15kV ) Load Interrupter (L.I.) electrical switches located on the base at Naval Station San Diego.

Demonstration testing is required to enable Navy-wide implementation of the process. Objectives of the test program are verification of cleaning effectiveness, development of safe work practices, and evaluation of potential impacts on electrical switchgear.

The project was conducted jointly with PWC San Diego Code 620 and leveraged about $125K of PWC funds to procure a $CO_2$ cleaning system.

## 1.2 BACKGROUND

Navy Public Works personnel are required to periodically clean large electrical switchgears known as Load Interrupter switches. For example, PWC San Diego needs to clean 740 high voltage switches every two years. The presence of foreign matter on high voltage power distribution equipment can cause dielectric breakdown and arcing between otherwise non conductive surfaces. The result is expensive equipment damage and power outages. They would like to be able to clean the switches without de-energizing the circuits because obtaining a scheduled power outage is usually difficult, and it usually requires the work to be done at night or on the weekends which requires overtime personnel.

Cleaning of power distribution equipment is performed as a preventative maintenance practice. The current practice is to de-energize the equipment and manually wipe surfaces with rags. Sometimes a synthetic oil, or grease, or a chlorinated solvent, such as trichloroethylene, are used with the rags. There are associated environmental problems. The cleaning solvents used are often ozone depleting substances (ODS) and their manufacture is being phased out as mandated by the Clean Air Act. The process generates solvent contaminated rags, which are a RCRA (Resource Conservation and Recovery Act) and TRI (Toxic Release Inventory) waste. Additionally, Executive Order 12856 requires all Federal facilities to achieve a 50% reduction in its toxic pollutants. And, as already stated, the cleaning must be performed at night or on weekends in order to avoid downtime to customers.

$CO_2$ pellets, which have a dielectric constant approximately equal to air, could be used to clean electrical switchgear, eliminating solvent usage. This technique can also be performed on energized equipment, thus eliminating the need to clean switches at overtime labor rates and scheduled power outages. Basic R&D for development of a $CO_2$ pellet delivery system compatible with high voltage equipment maintenance requirements was conducted by Puget Sound Energy Utility. Field testing of this technique at PWC San Diego was conducted to verify the cleaning effectiveness, evaluate potential impacts on Navy electrical switchgear, which differ from standard utility switches, and to develop safe work practices for Navy personnel.

## 1.3 SCOPE

This report summarizes the results of the project conducted jointly with PWC San Diego, Code 620, and NFESC, Port Hueneme, Code 421, leveraging funds from both agencies to evaluate the effectiveness of $CO_2$ pellet cleaning technology. The project included the design of the high voltage $CO_2$ system package, procurement of all parts, assembly of components on a flat bed truck, development of standard operating procedures, testing of system on energized high voltage switches, and evaluation of the results.

# 2.0 $CO_2$ CLEANING PROCESS DESCRIPTION

## 2.1 PROCESS

$CO_2$ pellet media blasting is a promising technique that can be used to clean energized power distribution equipment. The environmental advantage with a $CO_2$ cleaning system is that on impact, the dry-ice pellets sublime, or pass directly from the solid to gaseous phase, leaving no residual waste. Operationally, $CO_2$ pellets have a dielectric constant of 3.1 kV/mm at ambient pressure, enabling users to clean energized equipment with no sacrifice in safety. The $CO_2$ pellets have a surface temperature of -110$^0$ F and require gloves for handling. **All safety procedures are covered in section 4.0 and Appendix C &D.**

In the cleaning process the dry-ice particles are propelled at high velocities to impact and clean a surface. The particles are accelerated by compressed air, just as with other blasting type systems. Air pressures in the range of 80-100 psi are used requiring an air compressor capable of supplying this pressure which creates air flow rates up to 300 cfm (ft$^3$/min). Typical dry-ice pellet flow rates are 2-3 lb/min. The contaminants are removed by the $CO_2$ pellets in several ways. For brittle contaminants such as paint, the process creates a compression-tension wave between the coating and the substrate with enough energy to overcome the bonding strength. For more malleable or viscous coatings, more like that encountered in switchgear cleaning, the cleaning action is a flushing process similar to high pressure water. When the particles hit, they compress and mushroom out, creating a high velocity snow flow that flushes the surface. The dry ice shears and lifts the contaminant off the surface with no or very minimal surface damage. This shearing or lifting force is caused by the sublimation of the dry-ice pellets resulting in a sudden 400 fold increase in volume of the gas directed along the plane of the substrate. When compared to the familiar sandblasting, which uses a cutting or chiseling action, one could say that sandblasting is similar to using an ice pick whereas dry ice blasting is similar to using a spatula. Thus, in the anticipated use of the electrical switch components, there should be no substrate damage.

Obviously, if the process were used on softer substrates these would need to be examined on a case-by-case basis.

Upon striking the surface with the pellets, the contaminant is removed, usually falling to the ground or floor. The contaminant can now be removed, swept up, or in the case of outdoor switches blown out of the enclosure. The $CO_2$ pellets sublime (pass from the solid state to the gaseous state directly) and mix in the atmosphere. $CO_2$ gas is a naturally occurring compound which constitutes about 3% of the atmosphere.

## 2.2 HIGH VOLTAGE EQUIPMENT

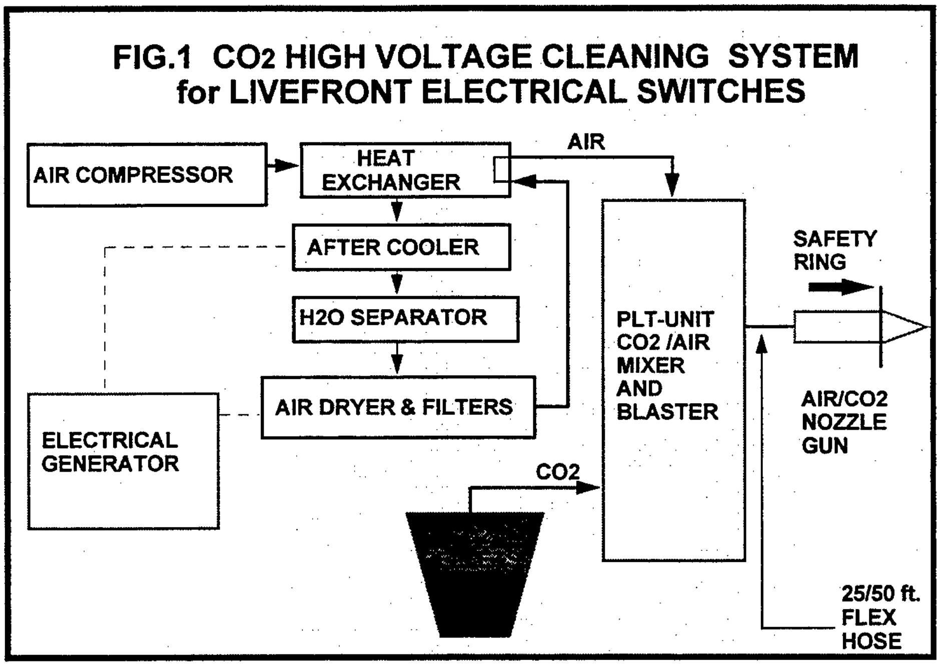
Basic R&D with a $CO_2$ cleaning system was conducted by Puget Sound Energy with emphasis placed on development of a $CO_2$ pellet delivery system compatible with high voltage equipment maintenance requirements (Ref.1). Puget Sound Energy was the first to use $CO_2$ cleaning on their pad mounted electrical switchgear. They worked together with Alpheus Cleaning Technologies, a supplier of the basic $CO_2$ equipment (the mixing unit, hoses, and gun) and A.B. Chance Co., who developed compatible high voltage "hot sticks" and nozzles (the delivery system for the air and dry-ice streams). A.B. Chance Co. (Ref.1) developed a series of hot sticks, which were modifications of standard industry hot sticks, and different nozzles to withstand the application of 100 kV for 5 minutes and produce a leakage current of less than 200 uA (microamps). Tests were done with and without pellet flow, holding voltage steps for 5 minutes. Results proved the hot sticks and nozzles to be safe well above voltage levels anticipated in field use of about 15 kV. Even the shortest stick, four feet long, could be used up to 230 kV with no more than 90 uA leakage current, too low to be felt by the operating technician. Similarly, the six foot hot stick and nozzle were tested to 500 kV with no more than 222 uA leakage current, again below detection threshold.

The high voltage equipment is combined with the remainder of the components as shown in Fig. 1. These components, described in detail in the next section, are the necessary elements of the system as procured and tested at PWC San Diego.

## 2.3 SYSTEM OPERATION

### 2.3.1 General Overview

The essential theory of operation, as shown in Fig. 1, is that it is necessary to generate a large volume of compressed VERY DRY air, transport it to the hot stick/gun/nozzle assembly, mix it with $CO_2$ pellets in the same hot stick/nozzle, and then direct the mixed stream in a safe manner to the object to be cleaned. The reason the air must be extremely dry is the tendency for a high voltage arc, often called flashover or tracking or arc blast, to develop along contaminated and wet surfaces. Since the $CO_2$ pellets have a dielectric constant equal to dry air, it is not desirable to reduce that safety factor with entrained moisture. Hence, much of the equipment in Fig. 1 is there primarily to perform this drying function.




The second safety factor is provided by the safety ring on the trigger/gun assembly which provides a safety point beyond which the operator may not go. The safety rule is this:

**Maintain "2 foot 2 inch" for 15 kV distribution.**

This means, just as it states, the operator may not approach within 2 foot 2 inch of any energized component. Since the shortest hot stick is three feet long, and adding the distance of the tip, and the trigger on the gun, the operator will never be closer than about four feet, well within the 2 foot 2 rule. In fact, as shown in the testing later, the operators didn't use the 3 foot hot stick much, preferring the 4 foot and 6 foot sticks. Also, it should be mentioned, that the operators are qualified high voltage personnel and well understand the dangers around high voltage equipment.

With these thoughts in mind, what follows is a brief discussion of each component in the system operation. They are presented in approximately the same order as the path the air and dry-ice flows take as they move through the system in Fig.1.

### 2.3.2 Equipment Operation

- **Compressor:** Provides high pressure air (up to 150 psi @ 300 cfm ) for (1) use as the propellant for the blasting medium, (2) the drive for the AIR LOCK motor in the PLT-HV, and (3) supply air for the pneumatic controls on the PLT-HV.

- **Heat-Exchanger:** Cools the air stream, heated by the compressor, in this first stage pass-through. The heat is used later to re-warm the air going to the air/$CO_2$ gun.

- **After-cooler:** Lowers the compressed air temperature. The compressor air at the inlet of the after-cooler can be as high as 100° F above ambient. Upon exit from the after-cooler it must be no higher than 122° F. Cooling is achieved by forcing cool ambient air to pass over the radiator. This unit functions similarly to an automobile radiator. It is powered by the generator or other power source.
- **Water separator and pre-filter:** Removes water and oil. The pre-filter has a differential pressure gauge (delta P) to provide visual indication of filter clogging. The green range indicates from 0 to 0.35 bar pressure drop and is the normal operating range. The red range indicates a clogged filter and the element must be changed before further operation.
- **Air dryer:** Provides adsorption of moisture to less than -40° F dew point at a maximum of 152 psig (10.5 barg) and a minimum of 58 psig (4 barg) and between 99 and 1237 scfm. It is a dual-regenerative, desiccant-filled dryer. The desiccant is Dryfill ( zeolite molecular sieve). The dryer is rated for continuous use. It is equipped with one inlet and two outlet pressure gauges (one for each column). The dryer has a moisture indicator that provides the unit with auto shut-off to prevent the passing of contaminated air.
- **After filter:** Prevents down stream dust carry over to PLT-HV. Canister is also fitted with a delta P gauge and operates the same as the pre-filter.
- **Dew point monitor:** Provides moisture contamination reading and is measured as dew point. Unit range is from -40° F to +15 °F with an adjustable alarm set-point. The alarm is set at -35 °F and will provide a visual and audible alarm when out of tolerance. It is physically mounted on the desiccant dryer and has its sensor mounted at the heat exchanger inlet for the final pass to the gun/nozzle.
- **Heat-Exchanger:** Re-warms the after-cooler dry compressed air in this second stage , further reducing the air moisture content to the PLT-HV hoses and nozzles.
- **PLT-HV:** Controls the air and $CO_2$ flow rates and pressure to the blast gun. Provides for visual confirmation of correct settings, emergency shut-off, pellet flow adjustment, and air pressure regulation to the blast nozzle. Unit contains the pellet storage and delivery hopper, AIR-LOCK pellet delivery motor, and the delivery hose connections.
- **Application hoses:** Provides two hose sections, 25 ft and 50 ft long. Each hose section consists of (1) high pressure air hose, (1) dry-ice pellet delivery hose, (1) #6 awg static discharge/grounding wire, and (1) protective sheath.
- **Application gun:** Provides operator with control of blast medium, via dead-man trigger, static/ directional control grip ring, which doubles as safety ring, and connection to insulated application "hot stick".
- **Application "hot sticks":** Provides connection from gun to directional nozzle while providing a safe working distance to the energized buss or L.I. switch.
- **Application nozzle:** Provides straight, 45°, and 90° angle direction control for blast medium. Attaches to hot sticks.
- **Generator:** Provides 120V power to the dew point monitor and the after-cooler. If another power source is available, this unit will not have to be started. In fact, during this testing it was not used since site power was generally available.

# 3.0 SYSTEM DESIGN AND PROCUREMENT FOR $CO_2$ CLEANING

## 3.1 GENERAL

NFESC and PWC San Diego personnel prepared the procurement package as a complete unit to Alpheus, having them integrate the components as specified by the Navy. Indeed, this was the cause of the initial delay in this project when PWC had previously attempted to procure the components separately, but the purchase was rejected because it did not meet some in-house funding requirements. Procurement as a complete unit reduces paperwork and multiple vendors and is the recommended approach. The procurement package as a complete unit had an estimated price of $125K.

## 3.2 DESIGN AND PROCUREMENT

NFESC and PWC San Diego worked together to take the results of the lessons learned from Puget Sound Energy and A.B. Chance, to design a system that had all the requisite components, have them skid-mounted for portability, and integrated for mounting on the bed of a Navy 5-ton flat bed truck with a 20 foot bed. PWC was able to obtain this truck prior to delivery and it should be noted that the cost of the truck is not included in the $125K purchase. The purchase order (copy in Appendix A) was given to purchasing on May 14, 1997; awarded to Alpheus on July 10, 1997; and equipment delivered to the Navy on Oct. 17, 1997. The Navy took delivery at the Alpheus factory in Rancho Cucamonga, CA, after two days of training (described in section 4.0) on safety, maintenance, and operation. The pertinent contract details are:

Equipment procured under Contract # N63387-97-RC-4006
Navy Public Works Center
2730 Mckean ST.
San Diego, CA. 92132
issued to:
Alpheus Cleaning Technologies
9119 Milliken AVE.
Rancho Cucamonga, CA. 91730
Dated May 14, 1997

The following specifications were developed for procurement of the system. They are excerpted from the procurement document for each component piece. See Fig.1 for system configuration. The manufacturers of the non- Alpheus supplied components were not specified, only the operating design points.

### 3.2.1 $CO_2$ Blaster/Mixer, Model PLT-HV

Carbon Dioxide Cleaner for cleaning energized electrical equipment. Lab tested and certified safe for use with insulated hot-stick/nozzles to 69k volts ac line to line. Nozzle must operate with less than 20 micro amps leakage current when measured end to end. System must be field proven for use on energized metal-clad enclosures. The $CO_2$ blasting pellets must maintain a high dielectric strength while producing a contaminant free surface without alteration or damage to the material blasted. The system must be environmentally benign, producing no waste for disposal. Blaster will have all pneumatic operation and controls. Stainless steel insulated housing and components. Dimensions: 24" wide x 36" long x 42" high; weight: 288 lb. empty. Lift hooks and forklift accessibility will be provided on all four sides. Must hold at least 120 lb. of $CO_2$ pellets capacity measuring 0.125 inch diameter and operate at 1 to 5 lb per minute of $CO_2$ pellets flow rate. Must operate with a system pressure from 40 - 300 psig for blast air provided by a skid mounted air compressor. The skid will provide for fork-lift access on all four sides.

### 3.2.2 Air Compressor

Compressor must be diesel engine driven, producing a minimum of 100 hp. Compressor capable of creating 80-150 psi at 300 cfm. and be of rotary screw type compression with a dual high/low pressure selection dial, high engine temperature and low oil pressure alarms. Provide a 2 stage dry type air filter, fuel level, air pressure and hour meter gauges. Must maintain US EPA sound requirements of 76 dBA at 7 meters. Compressor must provide moisture and contaminant free air at -40 degree F pressure dew point via an after-cooler and air dryer.

### 3.2.3 After Cooler/Air Dryer & Filter

Air from compressor is delivered to the after cooler / air dryer which must provide moisture and contaminant free air at -40 degree F pressure dew point. After-cooler/air dryer will be mounted on a skid for mobility, which will provide for fork-lifting on all four sides. Air dryer shall utilize dual regenerative process with alumina desiccant for continuous and automatic operation with less than 4 psig pressure drop to the blaster. Must be connected via quick-connect hose system to compressor and blaster. Must provide visual dew point indication and audible alarm when outside of given parameter. Provide a heat exchanger for blaster warm air, vibration absorber, air-cooled after-cooler and particulate after filter with differential pressure gauge. After-cooler controls to operate off of electrical power provided by a 10 kW air cooled diesel generator.

### 3.2.4 Diesel Electrical Generator

Provide electrical power by a 10 kW air cooled diesel generator mounted on the same skid as the after cooler/air dryer. Must operate at 120/240 volts ac for 10 hours operation at 50% load, and 5.9 hours operation at 100% load. Provide 12 volt dc key starter and built in 12V battery charger, and low oil shutdown.

### 3.2.5 Non Conductive Air Gun with Safety Ring, Assorted Blast Hoses, Model A. B. Chance Hot Sticks and Nozzles

High voltage blasting gun will come with a 45 degree swivel or 45 degree fixed hose connection and be provided with a (1) set of non-conductive hot sticks and nozzle tips tested and certified to ASTM standard F-711. The set will include (2) each of the following: 3 foot hot sticks, 4 foot hot sticks; 6 foot hot sticks; 45 degree nozzle tips; 90 degree nozzle tips; straight nozzle tips. Provide a electrical static absorbing front hand grip on nozzles. The blaster shall be connected to the blast gun and nozzle via 75 foot blast/ ice hose assembly (25 foot and 50 foot lengths) protected with an outer sheath. Sheath will hold (1) each: high pressure air hose, silicone $CO_2$ pellet delivery hose, and # 6 awg ultra flexible copper stranded, clear jacketed cable for grounding the blasting gun. Hose connections shall be fully compatible with the blasting gun, non-conductive nozzles, hot sticks, and PLT blaster unit.

## 3.3 AS DELIVERED COMPONENTS

Upon delivery the following component parts were installed on the Navy truck for delivery to PWC San Diego.

- $CO_2$ blaster/mixer, Alpheus MiniBlast model PLT-5HV.
- Air compressor, Sulair, Model 300H, 80-150 psi at 300 cfm.
- After cooler/air dryer & filter, Domnick Hunter, PNUEDRI; with dew point indicator, Model 8097; and ZEKS Air Dryer Corp, Model 301ACHA540; and heat exchanger, shell and tube type, API-Ketema, Inc., size 5-Y-18, 200 psig, $300^0$ F.
- Diesel electrical generator, Acme Motori, Model ADX 740, 10KW, 120/240 Volt Duplex.
- Non conductive air gun with safety ring, assorted blast hoses, Model A. B. Chance hot sticks and nozzles. All either Alpheus designs or manufactured to A.B. Chance specifications.

Details on the as-delivered system components are included in Appendix B for each manufacturer. A portion of each manufacturer's manual is reproduced in Appendix B, enough to identify each component, but not the entire document. An exception is the Alpheus PLT-5HV unit which, due to it being the key component of the system, is reproduced in entirety. All of the truck mounted components, except the compressor, were mounted on a skid for easy attachment to the truck. The skid drawing is shown in the first figure in Appendix B. For future users and purchases, the instructions given here will provide guidance. Ordering the Alpheus Model PLT-5HV will suffice to specify the system. That was the purpose in combining the order to a single package unit in the first place. Of course, contracting rules of sole source, providing alternate vendors, etc. can be imposed. Then one may have to "spec" the whole system, and sufficient information is given here to do that.

# 4.0 OPERATOR TRAINING and SAFETY ISSUES

## 4.1 TRAINING

A considerable amount of time and effort was spent in this area as befitting the complexity and relative abundance of equipment to be used. While much of the equipment were components familiar to the personnel, such as compressors, generators, heat exchangers, etc., the equipment related to the $CO_2$ usage generally was not. Also, when all the equipment was installed on the truck, it presented a rather daunting array of things, that invariably, leads to questions like, " OK, boss what do I do first"? The safety issues were no less imposing being a mix of familiar components and "new" $CO_2$ components, with the added exposure of high voltage risks.

To accomplish a sufficient and necessary amount of training it was decided to do it in two parts. One two day session was done at the manufacturer's plant, Alpheus Co. in Rancho Cucamonga, CA. A second session took place over a several day period at PWC San Diego. In attendance at all sessions were the following personnel:
NFESC- Edward Durlak
PWC San Diego- Messers Al Jo, Rolando Rosal, Richard Juarez, Louis Bannister
These personnel came to describe themselves as PWC " Dust Busters ... Who ya Gonna call?"

### 4.1.1 Training and Safety Issues at Alpheus Co.

The training at Alpheus over a two day period came in conjunction with the delivery of the system assembled on the truck to be transported to San Diego. This training was a mixture of lectures on operation, maintenance, trouble shooting, safety issues and hands-on demonstration of the various components. Alpheus did the training on its $CO_2$ equipment and brought in manufacturer's representatives to do the training on the other equipment. At the end of the two days a written 10 question test was given to the participants. It was graded, and for those that passed (all did) they were awarded an Alpheus CERTIFICATION FOR OPERATION, USAGE, AND MAINTENANCE OF $CO_2$ MINIBLAST, MODEL PLT-HV.

While the details of this training cannot be repeated in it's entirety in this report, the course outline, safety topics, test, and the certifications are given in Appendix C. For future Naval activities intending to pursue this technology, they will also have to take this company training, because Alpheus does not sell equipment without it. Even if another manufacturer should be used, this training would still be recommended.

### 4.1.2 Training and Safety Issues at PWC San Diego

While training at Alpheus was thorough on the $CO_2$ equipment aspects, it did not cover much material in regards to the electrical hazards or what standard operating procedures should be used at the Naval Station in the routine cleaning of the L.I. switches. It was left to the Navy personnel to develop these procedures. Using what was learned at Alpheus, the equipment manuals, electrical handbooks, and general switchgear knowledge, NFESC and PWC personnel met at San Diego over several days and by consensus developed a set of procedures and safety requirements applicable to $CO_2$ cleaning of L.I. switchgears. The San Diego personnel are very safety conscious and this resulted in each item of these procedures being discussed in detail including the type of personal protective equipment required. The procedures were reviewed and approved by Mr. William Hutchison, Utilities Division Director, PWC Code 620, San Diego. The eight page set of procedures including the Standard Operating Procedures (SOP) are presented in Appendix D, and are intended to be a **MANDATORY "lift-out" or "copy" Section** for all operators of $CO_2$ pellet cleaning equipment of electrical switchgears. The cover page of Appendix D is given here to show the scope in the body of the report. Also, the personal protective equipment required is reproduced from Appendix D and presented as Table 1.

## **APPENDIX D** (Excerpt)

## $CO_2$ PELLET CLEANING STANDARD OPERATING PROCEDURES

## Table 1
## PERSONAL PROTECTIVE EQUIPMENT

| | $CO_2$ STICKMAN | HOSEMAN | PLT-5HV OPERATOR | OBSERVERS |
|---|---|---|---|---|
| SAFETY ROPE | X | | | |
| KEVLAR FLASHCOAT | X | | | |
| NOMEX FLASHCOAT | | X | | |
| NOMEX COVERALLS | X | X | X | X |
| SAFETY GLASSES | | X | X | X |
| FACE SHIELD | X | | | |
| EAR PLUGS | X | X | X | X |
| EAR MUFFS | X | | | |
| NOMEX LINED GLOVES | X | | | |
| LEATHER GLOVES | | X | X | |
| HARD HAT | X | X | X | X |
| SAFETY SHOES | X | X | X | X |

# 5.0 SYSTEM TEST

## 5.1 TEST PROCEDURES

After taking delivery of the $CO_2$ equipment at the Alpheus factory, it was assembled on the 5-ton Navy truck and transported to San Diego on 22 Oct., 1997. The tests and evaluation of the $CO_2$ dry ice cleaning process were conducted at PWC San Diego over a several week period during Oct. and Nov. 1997. It was planned to test the cleaning effectiveness of the process, evaluate the impact on energized electrical switchgear, and to develop safe work practices. This was to be accomplished through a series of tests on L. I. switches at various base locations. Since it was intended to conduct these tests in the same manner that PWC personnel would do future routine maintenance cleaning, it was first necessary to develop a set of Standard Operating Procedures ( SOP ) that would govern the conduct of the test and test personnel. In fact this SOP was also necessary to satisfy PWC management before they would allow any personnel to participate. As stated in Section 4.1.2, the SOP was developed by NFESC and PWC personnel, approved by the PWC Utilities Division Director, and is presented in Appendix D. It can be copied for field use. In general, the SOP details the steps that the crew must follow when arriving at a site to conduct either a test, as in this case, or to do operational cleaning in the future. A brief summary is given here of the SOP in Appendix D:

- **System Overview:** Provides a summary of each component's function.
- **General Precautions:** Explains the type and nature of risks and exposure in this process.
- **Personal Protective Equipment:** Presents a table of what protective equipment is required for each person using this process, including observers.
- **Truck Equipment:** Presents a list of operational and safety equipment to be carried to each site.
- **Site Pre-Inspection:** This section gives a checklist of items to be accomplished before arrival at a site. This was found to eliminate many unpleasant surprises BEFORE the entire crew arrives. Included is determination of accessibility, type of switch, type of interlock, clearances, identification of good electrical grounds, power availability, hang safety signs, etc. One person can do this job in a quick site visit.
- **Site Arrival and Test (Cleaning ):** This section details the site preparation, cordoning of the area, and grounding of the equipment. Then a checklist is given to start the compressor engine, start the PLT-5HV, set the pressures, fill the ice hopper, and install the air and $CO_2$ hoses.
- **Cleaning Process:** Presents some items to follow during cleaning using $CO_2$ pellets.
- **Site Shutdown:** Presents a checklist to secure the equipment, and prepare for either the next site or a long term shutdown.

### 5.1.1 Certified Test Cleaning Crew

It was determined that the standard crew would consist of three certified by training personnel as follows:

Stickman: Operates the gun/hot stick/nozzle assembly and performs the $CO_2$ cleaning.

Hoseman: Holds the 25 or 50 ft hose ( 75 foot when joined ) in a manner to assist the stickman, and keeps the hose, as much as possible, from being dragged on the ground unnecessarily. He also relays signals to the PLT operator when the stickman is ready or not ready.

PLT Operator: Operates the PLT unit, sets all system pressures and flows, keeps $CO_2$ hopper supplied with pellets, and controls the emergency PLT shutdown switch. During the testing phase all personnel were assigned to gain work experience in each position.

## 5.2 TEST SAFETY STANDARDS

As previously stated, all safety standards are listed in the SOP, Appendix D, as well as the Personal Protective Equipment required in Table 1 and the SOP. These standards were rigidly followed during the tests.

## 5.3 TESTS CONDUCTED

A series of ten tests were conducted. Of these, seven tests ( 1 to 7 ) were on L.I. switches located throughout the Naval Station, including some at active piers. All switches were energized at 13.8 kV standard line voltage. Three tests (number 8 to 10 ) were conducted back at the PWC storage yard on specially prepared (dirty) insulators to determine, in a more controlled setting, cleaning effectiveness. Tests 8 to 10 were conducted at voltages up to 40 kV. The test data sheets for all tests are given in Appendix E. The results will be reviewed in the next Section 6.0.

During tests 1 and 2, a PWC representative of Occupational Safety and Health (OSH) was present to determine sound levels at various points at the site. From this data, presented in Appendix E, the sound exposures and hearing protection levels were determined for the SOP. The results showed the noise levels at the compressor to be 90dB (idle) and 98dB (run); at the nozzle blasting position to be 105-106dB; at the hoseman location to be 97-99dB. Single hearing protection is required above 84dB and double hearing protection above 104dB. Therefore, the nozzle operator (stickman), requires double hearing protection, ear plugs and ear muffs; and all others within a radius of 30 feet from the nozzle or a radius of 14 feet from the compressor, require single hearing protection, such as ear plugs.

## 5.4 TEST COMMENTS

### 5.4.1 Interlocks

The electrical switches used at Naval Station San Diego are classified as metal-enclosed Load Interrupter (L.I.) Switchgear. They come in a variety of configurations and mechanical interlocks. The purpose of the mechanical interlocks is to shut off the power before the access door to the L.I. switch can be opened exposing the interior of the cabinet. These interlocks are not required by PWC procedures and, in fact, the public utility companies routinely do not use or order them on their switchgear. However, unless they are specifically excluded when ordered, they come installed on the L.I. metal cabinets. These interlocks come in several configurations. Usually, though, they are of two types, a "Kirk Key Lock" configuration which requires a key, and a mechanical handle type which requires a handle to release the door. Either type, when cycled, shuts off the main power to the L.I. switch. This, of course, defeats the main purpose of the $CO_2$ cleaning process which is to clean the switch in the energized state. Therefore, it is necessary to remove or bypass these interlocks to use this process on energized L.I. switches.

A survey was conducted at PWC to determine if most of these switches on base contained some type of interlock. The following is a list of some of the L.I. switches at San Diego and it is noted all have interlocks. Discussions with other Navy PWCs indicate this is the typical situation.

- Power Controls, Inc. L.I. switch with Kirk Lock interlock.
- Kinney L.I. switch with mechanical handle interlock.
- Westinghouse L.I. switch with mechanical handle interlock.
- RSE L.I. switch with mechanical cover plate interlock.
- Sierra L.I. switch with mechanical handle interlock.
- Federal Pacific L.I. switch with Kirk Lock interlock.
- Industrial Electric Mfg, Inc. L.I. switch with Kirk Lock interlock.
- ITE Imperial Corp. L.I. switch with Kirk Lock interlock.
- General Electric L.I. switch with Kirk Lock interlock.

Since all the L.I. switches have some type of interlock, part of the test program was to determine how to clean the switches without interrupting the power to the switch. Unfortunately, due to the wide variety of L.I. switches, no single solution was found. Some interlocks were more difficult than others to bypass. Some of the switches could be accessed through side or back panels which did not have interlocks installed. Some had interlocks that could be removed from the exterior, by drilling out the fasteners. Some, and all the ones in the tests, were removed during short power outages of opportunity. This is probably the preferred method. Power outages at unoccupied piers, for example, are easier to get. Nevertheless, the presence of interlocks must be dealt with on a case-by-case basis for future Navy applications. It will be up to each Navy Station expert personnel to determine the best method in each case. PWC San Diego is committed to removing all interlocks on their 744 switches. When the interlocks are removed it is advised to put a permanent sign on each L.I. switch stating that the interlock is disabled.

### 5.4.2 $CO_2$ Pellets

The supplier of $CO_2$ pellets was Carbonic Products in Torrance CA., (213) 685-4846. These are manufactured using Alpheus pelletizing equipment, so they are within the specification of 0.125 inch dia. and 3/8 - 1/2 inch long. Carbonic will deliver on Mondays, Wednesdays, and Fridays. The cost is $0.19 to $0.20/lb. The pellets are stated to be good for about three days, however, if the box they are delivered in is kept sealed and a plastic sheet used to lay on top of the pellets, minimizing trapped air, they are useable up to 5 days. We usually took delivery on Monday and had no problem using the pellets up to the end of the week.

## 5.5 TYPICAL DAY WITH DUST BUSTERS

This section provides a description of the $CO_2$ cleaning system at the time of the testing. In photographic form it shows the equipment used, and follows the crew on a typical L.I. switch cleaning run. The following short narrative refers to Figures 2 to 15.

The $CO_2$ equipment was installed on the Navy truck at the Alpheus plant, **FIG. 2**, and then transported to PWC San Diego, **FIG. 3**. For a typical cleaning run, the truck will have all the necessary equipment put on board including the PLT unit, hoses, hot sticks, nozzles, $CO_2$ pellets, safety equipment, etc., and arrive at the site where the appropriate safety area is cordoned off, **FIG. 4**. The crew prepares the PLT unit, and starts assembling the hoses, **FIG. 5**; and then starts the compressor and fills the PLT with $CO_2$ pellets, **FIG. 6**. While the compressor is warming up, the generator, if required, can be started at this time also. After about 5 minutes warm up time the compressor is put in the run position and the valves to the PLT can be opened. The blast air and $CO_2$ pressure settings are adjusted on the PLT, **FIG. 7**. Note that the pellet delivery rate is set as a pressure on the PLT unit which translates to pounds per minute as given in the manual in Appendix B (also see **FIG. 16**). The application hot stick length and nozzle are selected and attached to the Air/$CO_2$ gun and safety ring, **FIG. 8**. A typical L.I. switchgear metal enclosed box is shown in **FIG. 9**. After the crew puts on the appropriate safety equipment, as specified it the SOP in Appendix D, the actual switch cleaning can begin, **FIG. 10**. Some of the PWC L.I. switches are located on the piers, **FIG. 11**. The interior of a typical L. I. switch is shown in **FIG. 12**, with the metal switches at the top and the fuses and insulators at the bottom. **Fig. 13** is a closer view of the Air/$CO_2$ gun and trigger assembly with the safety "deadman" trigger in the upper left and the operator safety ring in the right of the picture. After cleaning is completed the equipment is disconnected, assembled on the truck, and then moved to the next site or returned to the yard, **FIG. 14**. The crew is shown in **FIG. 15** after completion of one day in which five switches were cleaned.

FIG. 2 NAVY TRUCK AWAITING CO2 EQUIPMENT

FIG. 3 ASSEMBLED $CO_2$ TRUCK AT PWC SAN DIEGO

FIG. 4 ARRIVE ON SITE, CORDON TRUCK SAFETY AREA

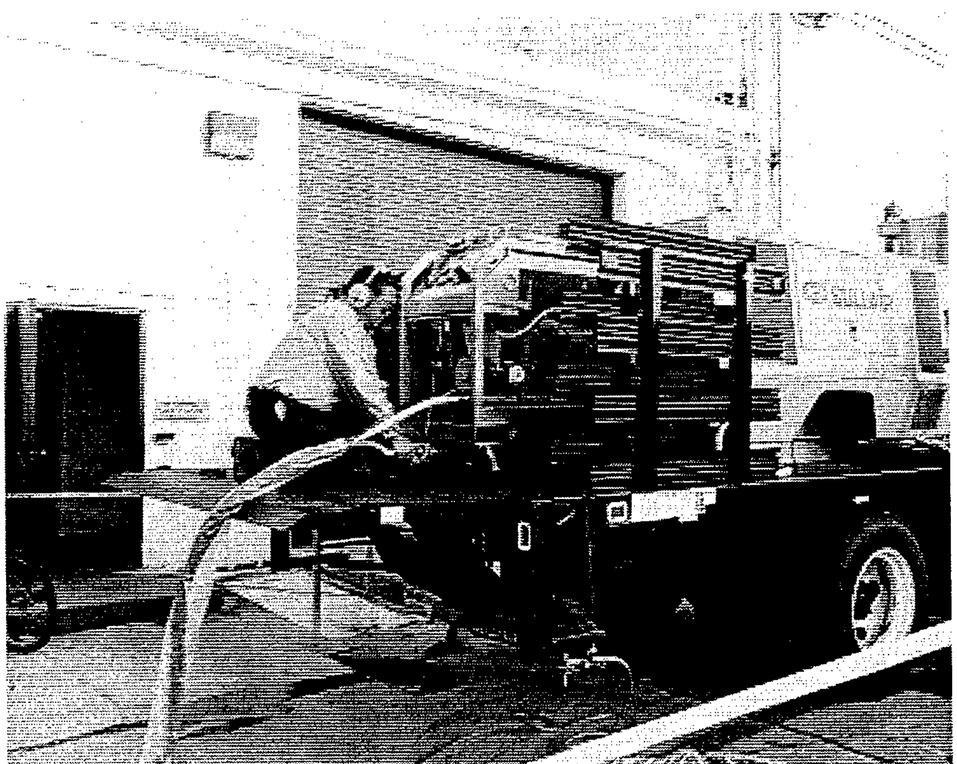


FIG. 5 PREPARE PLT, AIR and $CO_2$ ICE HOSES

**FIG. 6 START COMPRESSOR, FILL PLT WITH $CO_2$ PELLETS**

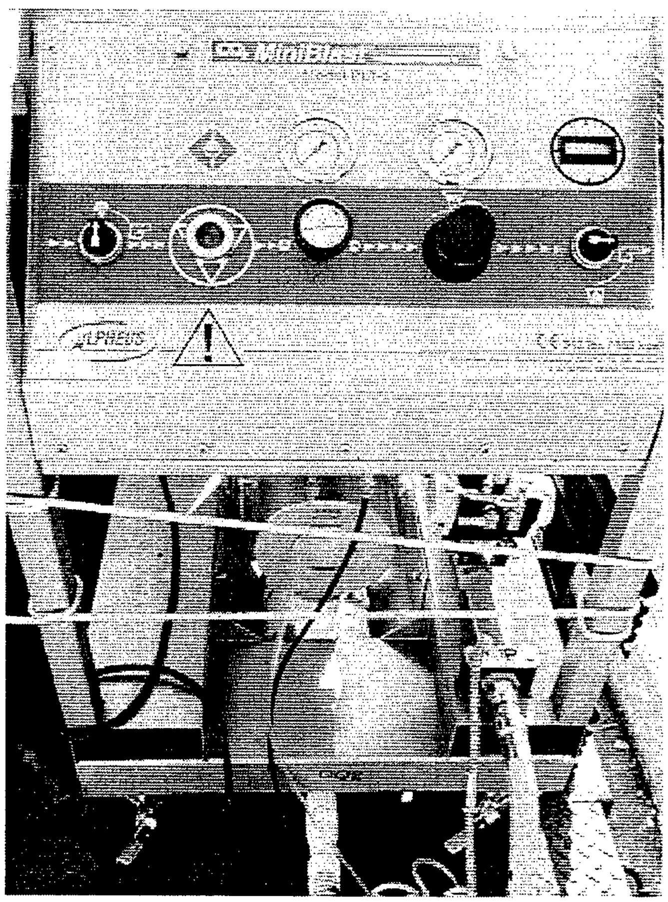


**FIG. 7 SET PLT AIR and $CO_2$ FLOWRATES**

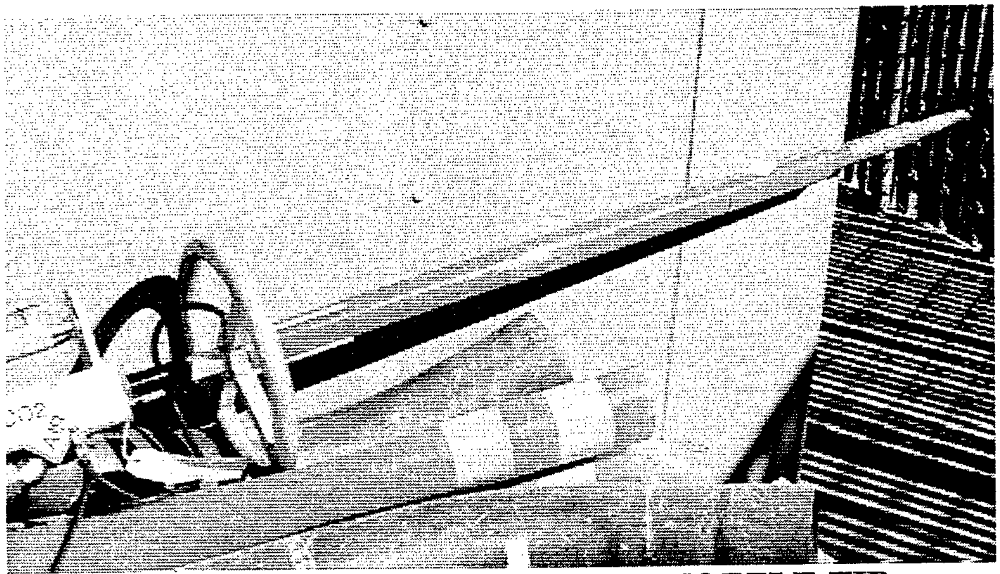


FIG. 8 ATTACH HOTSTICK & NOZZLE TIP

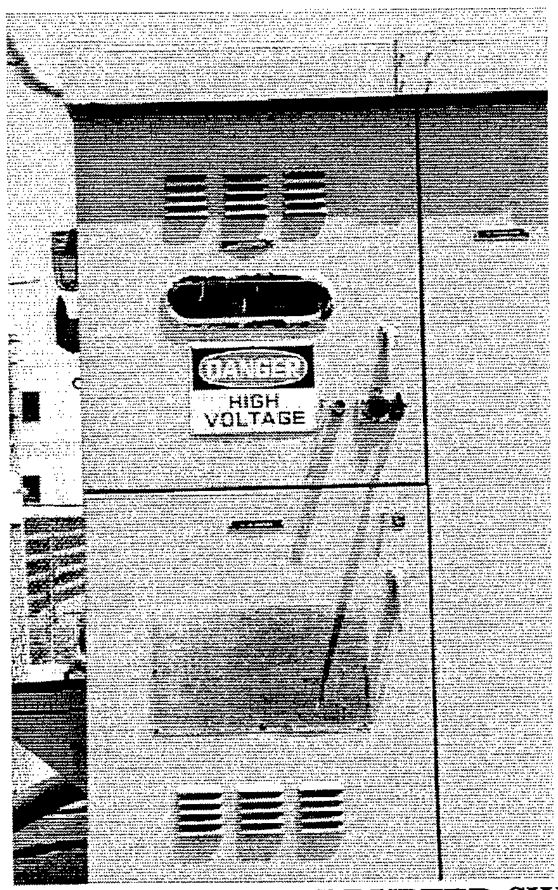



FIG. 9 TYPICAL LOAD INTERRUPTER SWITCHGEAR

**FIG.10 CLEAN LI SWITCH, BOX, INSULATORS, and FUSES**

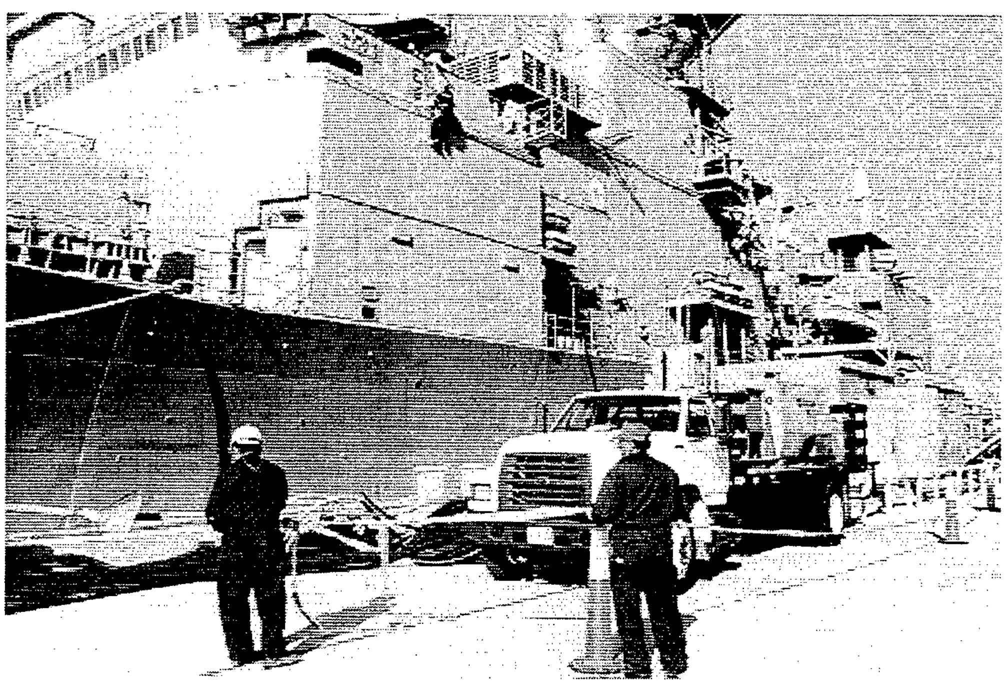


**FIG.11 CLEANING LI SWITCH ON NAVY PIER**

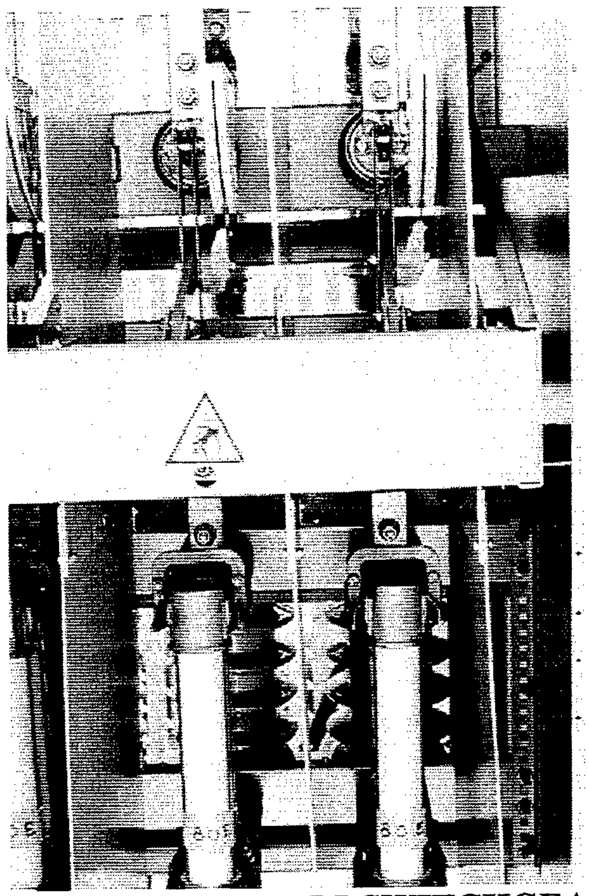


FIG.12  CLEANED LI SWITCHGEAR

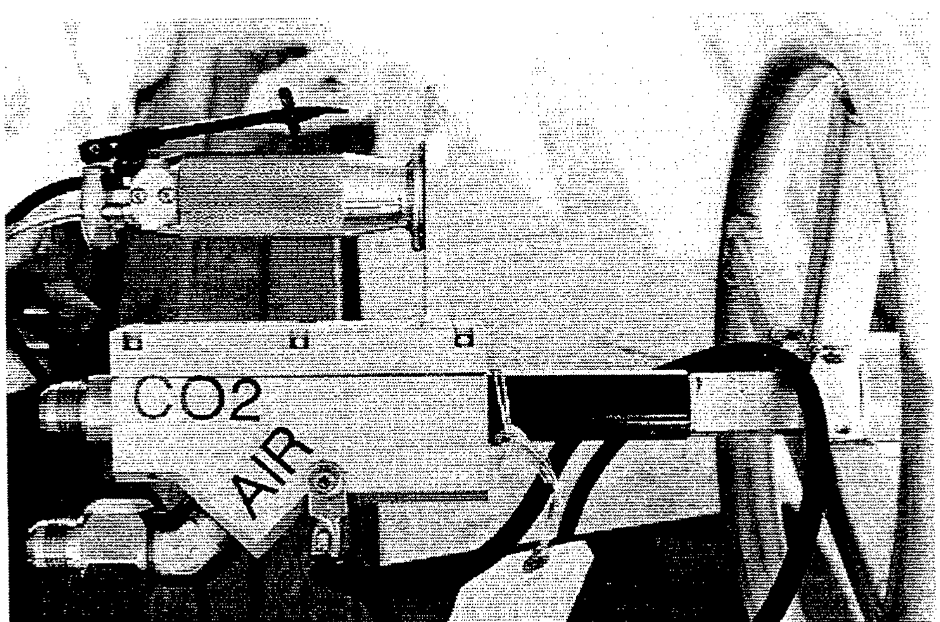



FIG.13  CO2 GUN, SAFETY RING, TRIGGER ASSEMBLY

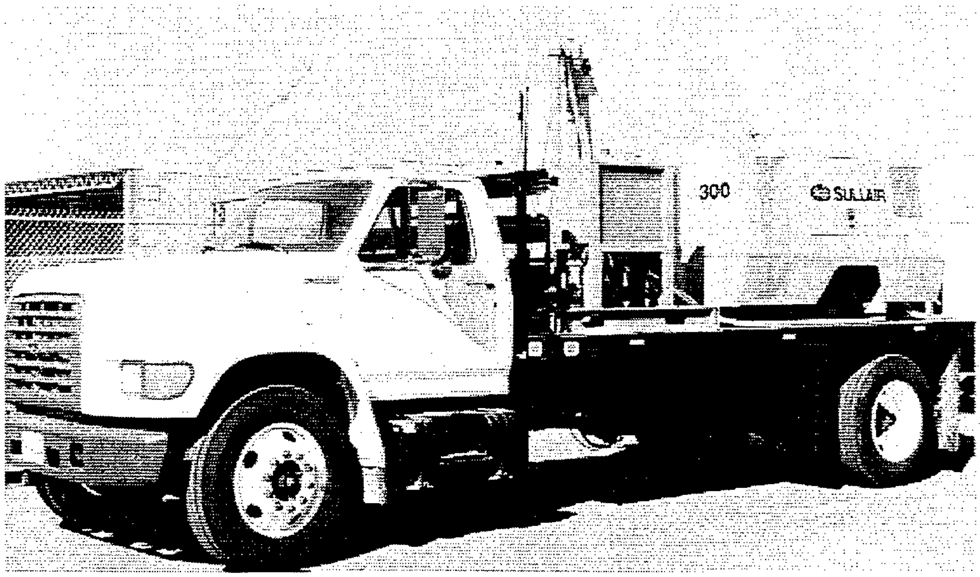



FIG. 14 LOAD TRUCK and RETURN TO YARD

FIG. 15 DUST BUSTERS CREW

# 6.0 TEST RESULTS and CONCLUSIONS

## 6.1 TEST RESULTS

A series of ten tests were conducted during several testing periods from late October to mid November, 1997. Of these, seven tests ( 1 to 7 ) were on L.I. switches located throughout the Naval Station, including some at active piers. All switches were energized at 13.8 kV standard line voltage. Three tests (number 8 to 10 ) were conducted back at the PWC storage yard on specially prepared (dirty) insulators to determine, in a more controlled setting, cleaning effectiveness. Tests 8 to 10 were conducted at voltages up to 40 kV. The field data sheets for all tests are given in Appendix E. Selected test details are presented in Table 2 and the remainder of the test parameters given in the data sheets.

**TABLE 2**
**$CO_2$ FIELD TEST RESULTS**

| TEST # | PLT AIR PRESSURE psi | PLT $CO_2$ FEED lb/min | TIME AT SITE hour | SWITCH CLEAN TIME minute | DIESEL FUEL USED gallon |
|---|---|---|---|---|---|
| 1 | 75 | 3.0 | 1.7 | 18 | 9.0 |
| 2 | 70 | 2.8 | 1.2 | 11 | 8.0 |
| 3 | 65 | 2.7 | 1.3 | 25 | 8.4 |
| 4 | 55/65 | 2.7/3.2 | 1.2 | 14 | 4.9 |
| 5 | 55 | 3.2 | 1.0 | 10 | 4.2 |
| 6 | 55 | 2.7 | 1.2 | 23 | 7.0 |
| 7 | 50 | 2.7 | 1.0 | 13 | 3.5 |
| 8 | 55 | 2.7 | N/A | 12 | 1.9 |
| 9 | 55 | 2.7 | N/A | 5 | 1.9 |
| 10 | 55 | 2.7 | N/A | 8 | 1.8 |

### 6.1.1 Discussion of Test Results

Field tests 1 and 2 were conducted on 30 October, 1997 on two identical L. I. switches ( FPE Federal Pacific). As can be seen from Table 2, it took almost two hours to clean the first L. I. switch. Although the crew had practiced in dry runs, this was the first actual site cleaning. As shown in Table 2, the blast air pressures and pellet feed rates were started on the high side, and were gradually reduced in future tests. The second switch was cleaned after lunch and was done in 1.2 hours, which, as can be seen in Table 2, would become about the average time the crew would take to arrive at the site, set up, clean, tear down, and depart. Of course, at site 2 the crew was already set up, having done test 1 in the morning. The visual and ultrasound inspection of these switches indicated that they were not too contaminated to begin with, but the removal of the dust and dirt was identifiable after cleaning. A problem was encountered starting with test 1 and becoming more pronounced with test 2. As the trigger was depressed on the air/$CO_2$ gun, see FIG. 13, the air and pellet flow would intermittently be stopped. At first the PLT unit with its many valves, controls, and safety shutdowns was suspected. After considerable trouble shooting, the cause was still not identified, and the intermittent nature further compounded finding the problem. Finally, near shutdown for the day, one of the crew noticed if the trigger were pressed down under the lever, upper left in FIG. 13, the air and pellet flows were normal. The fix was a simple adjustment of the clearances between these parts, lever and trigger, and the problem never occurred again. All three nozzles, straight, $45^0$, and $90^0$ were used in these tests to familiarize the crew.

During tests 1 and 2, a PWC representative of Occupational Safety and Health (OSH) was present to determine sound levels at various points at the site. From this data, presented in Appendix E, the sound exposures and hearing protection levels were determined for the SOP. The results showed the noise levels at the compressor to be 90dB (idle) and 98dB (run); at the nozzle blasting position to be 105-106dB; at the hoseman location to be 97-99dB. Single hearing protection is required above 84dB and double hearing protection above 104dB. Therefore, the nozzle operator (stickman), requires double hearing protection, ear plugs and ear muffs; and all others within a radius of 30 feet from the nozzle or a radius of 14 feet from the compressor, require single hearing protection, such as ear plugs.

Test 3, on 19 Nov.1997, is shown in FIG.10 and the results in Table 2, and data sheet 3. The site time for this test, 1.3 hours, reflected the crew becoming more familiar with the process, especially the setup and tear down time. As shown in Table 2, the switch cleaning time was 25 minutes, one of the longer ones, which was caused by several nozzle changes to clean in tight areas and to clean some difficult spots. Blast air pressure and pellet feed rate were reduced slightly. The other notable event was that this type L.I. switch had some insulators, shown at the top in FIG. 10, that had a protective coating of silicone grease ( INSTA-GEL). These insulators would not generally be good candidates for $CO_2$ cleaning unless they were extremely contaminated. The grease would then have to be reapplied anyway, and this could not be done with the switch energized as it was. The crew simply avoided them altogether, and that is the consensus recommendation for this situation.

Tests 4 to 7 were conducted on 20 NOV. 1997. A voltage regulator, located near site 5, was also cleaned the same day. The ability of the crew to clean four L.I. switches and the regulator in one day was due to the increased familiarity with the process, equipment, and site setup and tear down procedures. These tests were also designed to reflect more accurately what would become the standard cleaning routine, which would require the crew to do 5-6 switches per day. As shown in Table 2, the blast air pressure had been standardized at about 55 psi, and the $CO_2$ pellet feed rate about 2.7 lb/min. The site times were 1.0 to 1.2 hours per site and the actual switch cleaning time from 10 to 23 minutes each. The complete field data sheets are given in Appendix E.

The "typical day" photographs in Section 5.5 were taken largely from this series of tests. FIG. 4 shows the $CO_2$ truck arriving at site 5. FIGURES 5 and 7 show the PLT unit and hoses being connected at site 4. FIG. 11 is the L.I. switch at the pier of site 7, and the crew is shown in FIG. 15 at site 7 for the final cleaning of the day.

By now the switch cleaning had become somewhat routine. The following comments apply to tests 4 - 7. At site 4 the PLT unit was left on the truck and the hoses connected to it. The 25 and 50 foot hoses were used as necessary to reach the L.I. switches. This eliminated taking the PLT on and off the truck at each site, and became the standard procedure for the rest of the tests.

The G.E. switch at site 5 exhibited some ultrasound noise indicating minor electrical tracking. The noise was eliminated by cleaning. The short 3 foot hot stick and $45^0$ nozzle was used at this site. The voltage regulator located adjacent to the L.I. switch at this site was also cleaned.

The Westinghouse L.I. switch at site 6, located on the end of pier 2, was moderately dirty and indicated slight ultrasound noise tracking. After cleaning the visual inspection showed clean parts and the ultrasound noise was eliminated. The access to the back of the switch was restricted to 4-5 feet. Therefore, the 3 foot hot stick was used. At the start of the cleaning at this site, the PLT blast air pressure was 150 psi which was the same as the compressor outlet pressure. The pressure could not be adjusted at the PLT. The PLT was shut down while this new problem was investigated. After following the air flow path, it was found that the PLT operator had opened a wrong bypass valve on the PLT allowing full compressor air pressure to the unit. The system was reset and the subject valve "red tagged" to prevent future occurrences. Since the system is designed to run up to 300 psi, no harm was done to the system. It was noted that the PLT operator was taking his "first" turn at this position.

The last switch cleaned on this day at site 7 is a G.E. switch which serves ship power at pier 3. This switch also exhibited some ultrasound tracking noise which was eliminated during cleaning. This L.I. switch was mounted on a concrete pad and access to the rear panel was not possible. Therefore, the switch was cleaned from the front only and, since the switch was quite tall, the 6 foot hot stick was used to reach all areas. This was probably the most difficult switch to clean in terms of accessibility.

The next three tests (numbers 8 to 10 ) were conducted on 21 Nov. at the PWC storage yard on specially prepared (dirty) insulators to determine, in a more controlled setting, cleaning effectiveness. Tests 8 to 10 were conducted at voltages up to 40 kV. The field data sheets are given in Appendix E. These tests were done to provide some quantified before and after test data that was not possible to get in the field tests because leakage current measurements cannot be done on energized L.I. switches unless the circuits are somehow isolated. The insulators used in tests 8-10 were found in the shop area and prepared as follows. Test 8 was a straight sided gray plastic insulator and test 9 a white porcelain insulator with skirted sides. Both 8 and 9 were contaminated with a prepared mixture of egg whites, milk, sugar, molasses, and NO-LOX grease. They were soaked overnight and then dried in an oven. This contamination mixture simulated a worst case unit in field use. Test 10 was a straight sided black plastic insulator found in the shop area. It was dusty but otherwise not contaminated and was used as a control. The insulators were measured for leakage current before and after cleaning at several voltages. The insulators were cleaned while "hot" at 15 kV. Test results are shown in Table 3.

## TABLE 3
## LEAKAGE CURRENT TEST RESULTS

| TEST # | LEAKAGE CURRENT DIRTY | LEAKAGE CURRENT CLEAN |
|---|---|---|
| 8 | 20 mA@12kV ARC-FLASH | 0.2 mA@15kV NO ARCS |
| 8 | 60 mA@40kV ARC-FLASH | 0.1 mA@30kV NO ARCS |
| | | |
| 9 | 80 mA@20kV ARC-FLASH | 0.3 mA@15kV NO ARCS |
| 9 | 80 mA@40kV ARC-FLASH | 0.2 mA@30kV NO ARCS |
| | | |
| 10 | 0 mA@15kV NO ARCS | 0 mA@15kV NO ARCS |
| | | |

mA = MILLIAMPS kV = KILOVOLTS

Test 8 showed that leakage current dropped substantially from 20 milliamps to 0.2 milliamps at 12-15 kV after cleaning. Similarly, the leakage current dropped from 60 milliamps to 0.1 milliamps at 30-40 kV after cleaning. Arcing and flashover were present before cleaning at these voltages and were not present after cleaning. Similar results for test 9 are shown in Table 3. Test 10, the control, did not exhibit either arcing or any leakage current before or after cleaning. It should be noted that once an insulator does flashover, it is more susceptible to do it a second time because a "carbonized" path will often exist to provide the arc an easy route. These tests indicate the $CO_2$ cleaning process can provide very adequate cleaning even using a contaminated mixture not likely to be found in the field L.I. switches.

### 6.1.2 System Optimum Operating Settings

The system was operated over a range of settings of the blast air pressure from 50-100 psi and the $CO_2$ feed pressure from 50-65 psi. The $CO_2$ feed pressure is related to the $CO_2$ pellet delivery rate in lb/min as shown in FIG. 16. In determining the optimum settings, consideration is given to air and pellet delivery rates that are high enough to do the job, yet not so high as to waste pellets, cause substrate damage, or make the hot stick difficult to handle. The test results showed that after the first few tests (1- 4), in which the pressures were varied considerably, the crew began to use a consistently smaller range of settings. In tests 5 to 10 the range most consistently used was 50-55 psi for blast air pressure, and 55 psi (2.7 lb/min) $CO_2$ feed pressure. These settings were sufficient to do the cleaning. It is always possible to momentarily increase the settings to do spot cleaning of difficult areas or to empty the PLT hopper at the end of a job. Note that the compressor discharge pressures are fixed and all pressure changes are made at the PLT unit as discussed in the SOP, Appendix D. As stated in the PLT manual, to insure consistent pellet flow the feed rate pressure should not be set below 20 psi.

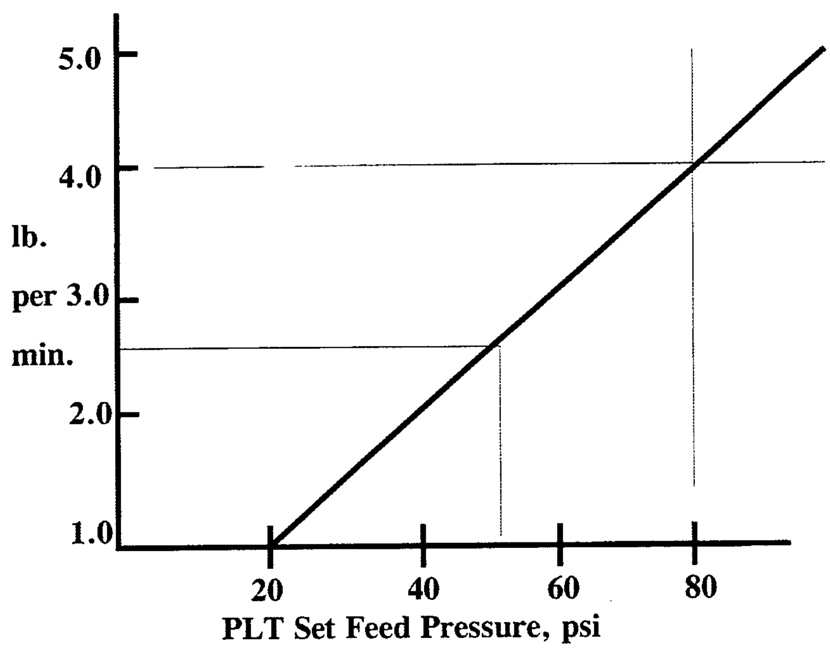



**FIG. 16 - $CO_2$ PELLET DELIVERY RATE**

## 6.2 LESSONS LEARNED

The primary lessons learned have already been discussed in the development of the Standard Operating Procedures given in Section 4.0 and Appendix D. In addition there were some lessons learned as a result of the testing conducted. The following comments are applicable:

- Do not leave any $CO_2$ pellets in the PLT hopper at the end of a job or the end of the day. The pellets will tend to freeze to a solid block and cause problems when the system is started again. Consequently when filling the PLT hopper, estimate how much $CO_2$ will be required and put in that quantity. It is very easy to add more during the job. After a few jobs this will be easy for the operators to estimate. At the end of cleaning, empty the hopper by running the ice through the nozzle.
- The sharper the nozzle angle, particularly $90^0$, the more the pellets are degraded coming out, and, thus, the less efficient the cleaning. The $90^0$ nozzle is also a little harder to manage at the higher blast pressures. Use it when necessary to clean tight spots, around bends, and other hard to reach spots. The $45^0$ nozzle is probably the best choice for most cleaning. Also, the four foot hot stick was used the most.
- Always check the electrical grounds. This is stated in the SOP very clearly. But even if the operator is doing a cleaning job of non electrical parts, the $CO_2$ pellets going through the PLT and hoses can still generate a static electrical charge and be a potential source of shock. Properly grounding the PLT and air gun will eliminate this problem.
- If the area around the L.I. switch is very dusty, the blast air coming out of the nozzle can create a dust cloud. A mask may be required. One solution may be to lay down some material like indoor-outdoor carpet to act as a dust suppresser. This was not a problem during the tests conducted at PWC.
- For some of the tall L.I switches, reaching the interior can be difficult with the short three foot hot stick. Using the six foot hot stick was adequate for all the conditions encountered in these tests. It was suggested that the crew carry a short box or ladder to stand on if necessary. After consideration, this idea was rejected. The hazard of falling far outweighs any advantage gained. If it can't be reached with the long hot stick, do not clean it. Wait for a scheduled outage.
- The usual operating practice for working live parts in inclement weather should be observed. Rain, snow, and high humidity days are to be avoided for $CO_2$ cleaning.
- Communication is important between nozzle operator (stickman) and PLT operator. The high noise level indicates a series of hand signals should be used to indicate start, stop, etc. Most operators do this instinctively, but it should be practiced by the crew.
- Prior to cleaning, if flashover or burn marks are noted on the parts, a determination should be made before commencing as to whether the part should be replaced. Consult the foreman or supervisor.

## 6.3 $CO_2$ PROCESS ADVANTAGES

Electrical arcing and flashover are a major cause of failure for energized L. I. switchgear. Contamination induced flashovers are a safety concern for employees, Naval personnel, and the public. The subsequent power outages and equipment damage inconvenience users and cost the Navy money. As an example, the following is a short history of the power outages at various locations within PWC San Diego immediately prior to this project. The August incident of the catastrophic failure of the L.I. switch at NAS North Island is shown in FIG. 17.

**1997**

- January -NAVAL AMPHIBIOUS BASE - L.I. fuse blew, took 2 men 4 hours to replace.
- April - NAVAL STATION - Oil switch on Pier exploded, Discussed in Sec. 6.3.2
- July - NAVAL STATION - Pier 7 switch shorted, U.S.S. Pelilieu power out 4-5 hours, no record of this switch ever being cleaned.
- August - NAVAL AIR STATION, NORTH ISLAND - Switch insulators dirty, failed at porcelain insulator, entire L.I. replaced. Power out 3 hours and then another 24 hours to replace L.I. Docked carrier was U.S.S. Constellation.
- September- NAVAL STATION - Pier 2 L.I. switch failed and replaced. Power out to U.S.S.Boxer 4 hours, then power out another 3 hours to replace L.I.

While it cannot be guaranteed that $CO_2$ cleaning would have avoided all these instances, a regularly scheduled cleaning program would certainly help. Scheduled $CO_2$ cleaning of energized L.I. switches is a safe and efficient way to prevent failures. $CO_2$ pellets are a natural fire extinguisher and exhibit a dielectric strength slightly better than air ( 31 kV/cm). The pellets remove surface contamination without damage and vaporize on contact, leaving no environmentally hazardous secondary waste stream. The benefits of using the $CO_2$ cleaning technology can then be stated as:

- Cost effective
- Electrically safe process
- Improve system reliability
- Improve customer service
- Environmentally friendly

### 6.3.1 Comparison to Existing Method

The existing method of cleaning L.I. switches is to obtain a scheduled power outage and then manually open and clean the switches using rags and some type of solvent which may generate some hazardous material, such as volatile organic compounds (VOCs). According to PWC personnel, it takes about a 3.0 hour outage for a 3 - 4 man crew to do the job. As seen from Table 2, the $CO_2$ process takes a 3 man crew about 1.0 to 1.2 hours to do the same cleaning. Thus the two methods are similar in labor time, about 1.5 hours less with $CO_2$. However, the $CO_2$ method could result in even further cost savings if the scenario is considered as follows.

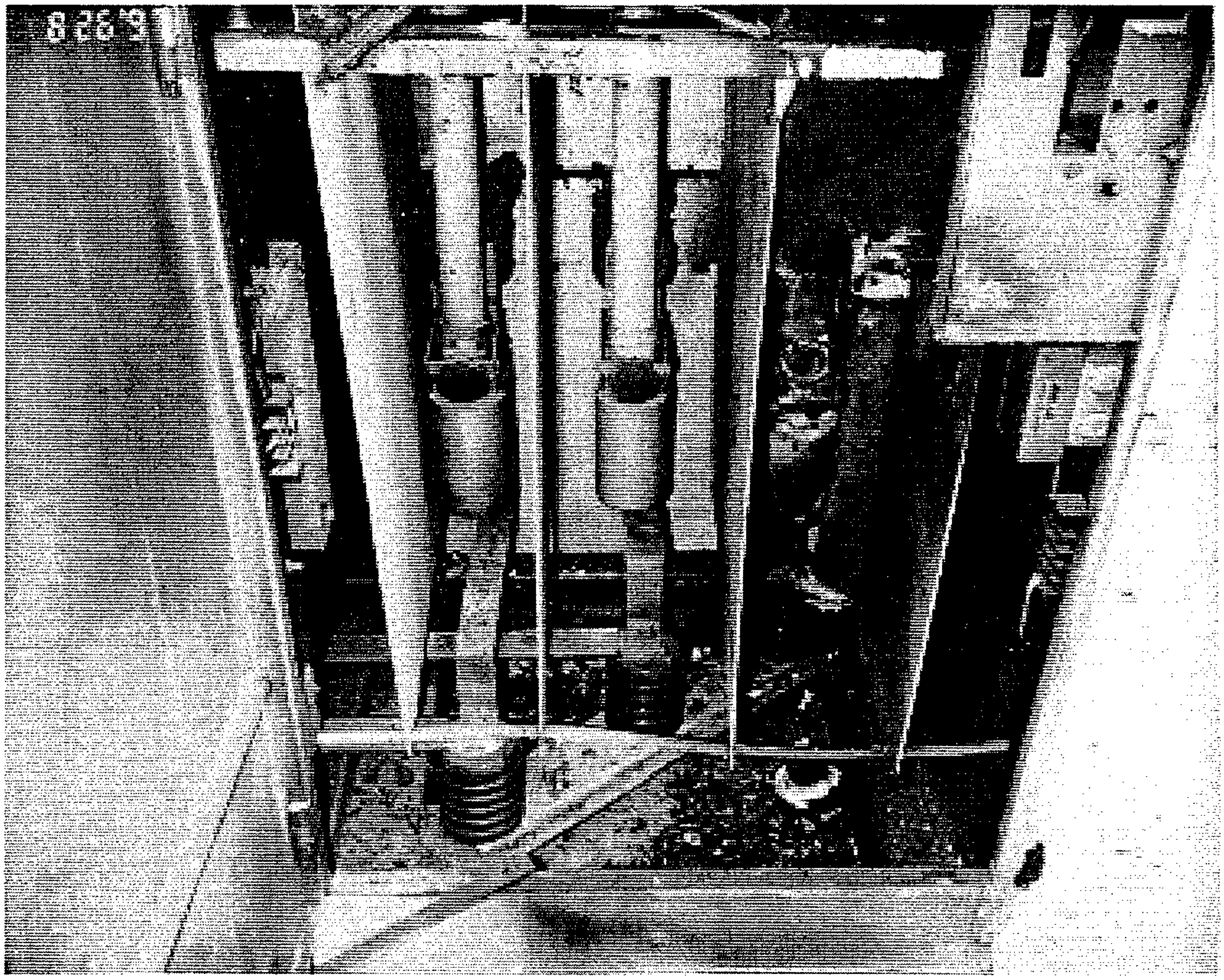


**FIG. 17 EXPLODED L.I. SWITCH (right side) on PIER PROVIDING POWER to U.S.S. CONSTELLATION - NAS NORTH ISLAND, CA**

The existing rag cleaning method depends on getting the power outage approval for cleaning the switch. That is usually difficult and, if approved, usually will result in the crew working nights or weekends at premium pay. Assume the approval is obtained and the crew goes out to clean the switch manually. As shown in the testing of the $CO_2$ process, the crew can clean 5-6 switches in a day. To clean 5-6 switches by the existing manual method, and obtaining the corresponding power outage approvals (5 or 6, not 1) for the same day, is simply not going to happen. Hence, the manpower can be more effectively used with the $CO_2$ process, since it is dependent only on PWC schedule not the users schedule. Having the whole crew come in on the weekend to clean one or two switches can be avoided. Therefore, at a minimum, it is estimated that the man-power can be reduced at least 1.5 hr. per switch with the $CO_2$ process.

An example of the difficulty in obtaining a power outage at PWC San Diego can be seen from the following. An outage was requested for 2-3 August to clean and inspect a few switches using the manual method for baseline data for this test. The outage was still not approved when the actual switch cleaning started in November. Note the requested date was a weekend which is typical for most scheduled cleanings.

### 6.3.2 Cost Benefits

The real cost benefits of the $CO_2$ process are those that will be realized by having a regularly scheduled switch cleaning program, conducted at the schedule and convenience of PWC, and the avoidance of power outages and their attendant crises responses. The use of regularly scheduled preventive maintenance versus crises maintenance represents a cost savings that will vary at each Navy activity and is often difficult to estimate.

An example of crises maintenance was the April occurrence of the switch failure incident at the PWC San Diego pier as noted in Sec. 6.3. This particular failure happened when the author was present at San Diego and was at the pier with the PWC crew in response to the emergency. At the time the U.S.S. Cleveland, a Landing Platform Dock ship, had just docked upon returning from a 6 month deployment. It was the ships homecoming, and friends and family were waiting at the pier. A 600 amp. switch downstream from the main switch caught fire, exploded, and immediately shut down the pier power. Since the ship could not transfer to pier shore power it had to keep the engines running to supply power. The result was that the ship was not able to secure until the repair was made. It took about five hours to restore power. During that time the ship, crew, and Navy were impacted as follows.

- Most of the crew had some delay in leaving ship.
- Some of the crew and the Engineering Duty Officer had to stay on board 5 extra hours while the engines were running, possibly missing travel or leave connections.
- The ship burned an extra 300 gallons of fuel each hour.
- The fire department responded to the fire.
- Two contractors and 4 - 5 Navy personnel spent most of the day on the problem.

Using the preceding information and examples a reasonable estimate of cost benefits can be made.

MANPOWER SAVINGS

Using the scenario that the $CO_2$ process produces better scheduling and utilization of manpower in switch cleaning, and minimizes premium labor rates a savings of 40-50% in cleaning time could be realized. PWC has 744 L.I. switches. If about one quarter are cleaned each year, at 1.5 man-hours savings per switch, the savings would be:

(744)switches X 0.25 X 1.5 hr/switch X $60/hr = $16K/yr.

POWER OUTAGE SAVINGS

If an unscheduled power outage occurs the cost is dependent on the number of people affected, length of outage, damage to equipment, loss of production, and other unknown costs like those given in the U.S.S. Cleveland example ( delays and inconveniences to personnel, these are what the Navy currently calls Quality Of Life issues). It would be reasonable to assume that a power outage could affect 50 people for one day. One such incident then would cost, considering only the lost labor:

50 X 8 hr X $60/hr = $24K

Savings could be much greater if more power outages or other costs are also considered. Some at PWC estimate that costs could be much higher for power outages associated with catastrophic failures.

Using this conservative estimate of 1.5 man-hours per switch cleaned, and one power outage avoided per year, the yearly savings would be $16K plus $24K = $40K/yr. A simple pay back of the $125K capital cost of the equipment is about 3 years.

An independent estimate given by the Utilities Division Director at PWC San Diego is that it will save him one to two man-years labor at about $55K per year. This would reduce the simple pay back to 1.2 - 2.2 years, depending on man-years saved, and is in reasonable agreement with the preceding analysis.

## 6.4 REQUIREMENTS TO IMPLEMENT

The specifications to implement the $CO_2$ cleaning technology are adequately described in this report. The components of the system are shown in FIG. 1; they are described in detail in Section 3.2; and the actual procurement document is given in Appendix A. The total procurement cost was $125K, not including the cost of the truck. PWC provided a five ton, 20 foot flat bed truck, which could add an additional $25-30K to the cost. The procurement package was structured as a complete unit as it was purchased from Alpheus Co. The individual components could be purchased separately, and then assembled by the user. A sketch of the skid mounted components is given in Appendix B with the equipment manuals. The skid includes everything except the air compressor which has its own attach points for the truck. The generator, mounted on the skid, provides power only to the after cooler and the dew point indicator. As previously stated, the generator was used in the initial training runs, but was not used in the field tests because power was always available at the L.I. switches. This would not be true if the crew were responding to a trouble call where the power was out of service. It is still recommended as part of the package, but, as stated, it was not used much in these tests.

PWC San Diego is the first Navy organization to implement this technology. This report provides sufficient information for other Navy facilities to evaluate it for their use. The author has informally contacted the other PWCs to inform them of the testing and evaluation of the $CO_2$ technology.

There are other private industry utility companies that are considering or already using this technology. Those utility companies, which the author has contacted, include DWP Los Angeles, CA; City of Calgary Utility, Calgary, Canada; Grant County Public Utility, Ephrata, WA; Anoka Electric Utility Cooperative, Ramsey, MN; Wickens Industrial, Toronto, Canada; and Puget Sound Energy, Bellevue, WA.

Cooperative information has been exchanged with these companies during the course of this project. Anoka Electric provided a list of their procedures for use in this report and in turn a copy of the SOP developed in this testing has been provided to them. Anoka stated that their total system costs, including the truck, was about $160K. This is in good agreement with the NFESC cost estimate given as $125K plus $25-30K for the truck.

## 6.5 CONCLUSIONS

The demonstration testing of the $CO_2$ cleaning process was required to evaluate the process for potential Navy-wide implementation. As stated in the Objectives of the test program, the primary goals were verification of cleaning effectiveness, development of safe work practices, and evaluation of potential impacts on electrical switchgear. The safe work practices were developed through the Standard Operating Procedure which has been discussed in detail in Sections 4.0, 5.0, and Appendix D. The test results, discussed in Section 6.0, show that the $CO_2$ cleaning process is a method that can be safely used to clean energized Load Interrupter Switchgear, performs in an efficient manner, and does not cause any damage to the component parts.

The cost benefits of the $CO_2$ process are those that will be realized by having a regularly scheduled switch cleaning program, being conducted at the schedule of PWC, and avoiding power outages and their crises responses. The use of regularly scheduled preventive maintenance is a cost savings that will vary at each Navy activity.

Using a conservative estimate of savings of 1.5 man-hours per switch cleaned, and one power outage avoided per year, the yearly savings would be $40K/yr. A simple pay back of the $125K capital cost of the equipment is about 3 years. A shorter pay back of 1.2 - 2.2 years could be attained if higher labor savings are obtained as given in Section 6.3.2. Savings could be even greater if more power outages or other higher power outage costs are considered.

The benefits of using the $CO_2$ cleaning technology are summarized as:

- Cost effective
- Electrically safe process
- Improved system reliability
- Improved customer service by reducing power outages
- Improved Quality Of Life for Navy personnel
- Environmentally friendly

It is recommended that Navy activities consider the use of this technology to improve the methods currently used in cleaning Livefront Electrical Switchgear.

## REFERENCES

1. Cleaning Energized Equipment Using Dry Ice Pellets, Paper by Ranjan Bhagat, Puget Sound Power and Light, Bellevue, WA. Submitted to The Sixth International Conference On Transmission and Distribution Construction and Live Line Maintenance conference, September 12-17, 1993, Las Vegas, NV.

# APPENDIX A

## $CO_2$ SYSTEM PROCUREMENT CONTRACT

REQUEST FOR CONTRACTUAL PROCUREMENT—NAVCOMPT FORM 2276 (8 PT) (REV. 8-81) S/N 0104-LF-702-2761 

| | |
|---|---|
| 1. THIS REQUEST MUST BE ACCEPTED ON A DIRECT CITATION BASIS ONLY AND IS SUBJECT TO THE CONDITIONS LISTED ON THE REVERSE SIDE. | 2. DOCUMENT NUMBER<br>N63387-97-RC-4006 |

| 3. REFERENCE NUMBER | 4. FUNDS EXPIRE ON | 5. DMS RATING | 6. PRIORITY | 7. DATE REQUIRED | 8. AMENDMENT NO. |
|---|---|---|---|---|---|
| N63387-7118-1575 | N/A | C-9 | 09 | 31 OCT 1997 | |

| | |
|---|---|
| 9. FROM N63387 COMMANDING OFFICER<br>NAVY PUBLIC WORKS CENTER<br>BOX 368113, 2730 MCKEAN ST. STE 1<br>~~SAN DIEGO, CA 92136-5294~~ | 10. FOR DETAILS CONTACT:<br>AL JO<br>TEL: (619)556-7344<br>FAX: (619)556-7339 |
| 11. TO: UIC<br>N00244 COMMANDING OFFICER<br>FLEET AND INDUSTRIAL SUPPLY CENTER<br>REGIONAL CONTRACTS DEPT. CODE 210<br>937 NORTH HARBOR DRIVE<br>SAN DIEGO, CA 92132-0060 | 12. MAIL INVOICES TO:<br>TO BE SPECIFIED IN CONTRACT |

13. ACCOUNTING DATA TO BE CITED ON RESULTING CONTRACTS

| A. ACRN | B. APPROPRIATION | C. SUBHEAD | D. OBJ. CLASS | E. BU. CONTROL | F. SA | G. AAA | H. TT | I. PAA | J. COST CODE | K. AMOUNT |
|---|---|---|---|---|---|---|---|---|---|---|
| | 97X4930 | NE1E | 000 | 77777 | 0 | 063387 | 2F | 000000 | 00631182426E4 | $125,000.00 |

| | | |
|---|---|---|
| 14. AMOUNTS WILL NOT BE EXCEEDED IN THE OBLIGATION DOCUMENT WITHOUT PRIOR WRITTEN APPROVAL FROM THE ISSUER. | L. TOTAL THIS DOCUMENT | $125,000.00 |
| | M. CUMULATIVE TOTAL | $125,000.00 |

15. PROCUREMENT BY CONTRACT OF THE FOLLOWING ITEMS IS REQUESTED
THESE ITEMS ☐ ARE ☒ ARE NOT INCLUDED IN THE INTERSERVICE SUPPLY SUPPORT PROGRAM AND REQUIRED INTERSERVICE SCREENING ☒ HAS ☐ HAS NOT BEEN ACCOMPLISHED

| A. ACRN | B. ITEM NO. | C. FSC | D. DESCRIPTION (NAT. STOCK NO., SPEC. AND/OR DRAWING NO., ETC.) | E. QUANTITY | F. UNIT | G. ESTIMATED UNIT PRICE | H. ESTIMATED AMOUNT |
|---|---|---|---|---|---|---|---|
| | 001 | 7910 | CARBON DIOXIDE CLEANING MACHINE. FOR CLEANING ENERGIZED EQUIPMENT. LAB TESTED AND CERTIFIED SAFE FOR USE WITH INSULATED HOT-STICK NOZZLES TO 69K VOLTS AC LINE TO LINE. NOZZLES MUST OPERATE WITH LESS THAN 20 MICRO AMPS LEAKAGE CURRENT WHEN MEASURED END TO END. SYSTEM MUST BE FIELD PROVEN FOR USE ON ENERGIZED METAL-CLAD ENCLOSURES. THE CO2 BLASTING PELLETS MUST MAINTAIN A HIGH DIELECTRIC STRENGTH WHILE PRODUCING A CONTAMINANT FREE SURFACE WITHOUT ALTERATION OR DAMAGE TO THE MATERIAL BLASTED. THE SYSTEM MUST BE ENVIRONMENTALLY BENIGN, PRODUCING NO WASTE DISPOSAL.<br><br>BLASTER UNIT MUST HAVE ALL PNEUMATIC OPERATION AND CONTROLS. STAINLESS STEEL INSULATED HOUSING AND COMPONENTS. | 01 | EA | $125,000.00 | $125,000.00 |

| | |
|---|---|
| 16. SEE ATTACHED PAGES FOR DELIVERY SCHEDULES, PRESERVATION AND PACKAGING INSTRUCTIONS, SHIPPING INSTRUCTIONS AND INSTRUCTIONS FOR DISTRIBUTION OF CONTRACTS AND RELATED DOCUMENTS. | I. GRAND TOTAL |

17. TRANSPORTATION ALLOTMENT *(Used if FOB Contractor's plant)*

| | | |
|---|---|---|
| 18. I CERTIFY THAT THE FUNDS CITED ARE PROPERLY CHARGEABLE FOR ITEMS REQUESTED. | AUTHORIZING OFFICIAL (NAME, TITLE AND SIGNATURE)<br>RESTY ELEFANTE RACA | DATE<br>5/14/97 |
| 19. THIS REQUEST IS ACCEPTED AND THE ITEMS WILL BE PROVIDED IN ACCORDANCE HEREWITH. | ACCEPTING OFFICIAL (NAME, TITLE AND SIGNATURE) | DATE |

Exception to SF 36
Approved by NARS 7/75

| STANDARD FORM 36, JULY 1966<br>GENERAL SERVICES ADMINISTRATION<br>FED. PROC. REG. (41 CFR) 1-16.101 | CONTINUATION SHEET | REF. NO. OF DOC. BEING CONT'D<br>N63387-97-RC-4006 | PAGE 2 | OF 4 |
|---|---|---|---|---|

NAME OF OFFEROR OR CONTRACTOR

| ITEM NO | SUPPLIES / SERVICES | QUANTITY | UNIT | UNIT PRICE | AMOUNT |
|---|---|---|---|---|---|
| | DIMENSIONS: 24" WIDE X 36" LONG X 42" HIGH X 288 LBS EMPTY. LIFT HOOKS AND FORKLIFT ACCESSIBILITY WILL BE PROVIDED ON ALL FOUR SIDES. MUST HOLD AT LEAST 120 LBS OF 0.125 DIAMETER CO2 PELLETS AND OPERATE USING 1-5 LBS PER MINUTE. MUST OPERATE WITH SYSTEM PRESSURE FROM 40-300 PSIG FOR BLAST AIR PROVIDED BY A SKID MOUNTED COMPRESSOR., THE SKID WILL PROVIDE FOR FORKLIFT ACCESS ON ALL FOUR SIDES. | | | | |
| | COMPRESSOR MUST BE DIESEL ENGINE DRIVEN PRODUCING A MINIMUM OF 100 HP. CAPABLE OF CREATING 80-150 PSI AT 300 CFM. BE OF ROTARY SCREW TYPE COMPRESSION WITH A PRESSURE SELECTION DIAL. HIGH ENGINE TEMP AND LOW PRESSURE ALARMS. PROVIDE A TWO STAGE DRY AIR FILTER, FUEL LEVEL, AIR PRESSURE AND HOUR METER GUAGES, MUST MAINTAIN U.S EPA SOUND REQUIREMENTS OF 76 DBA AT 7 METERS. COMPRESSOR MUST PROVIDE MOISTURE AND CONTAMINANT FREE AIR AT -40 DEGREE PRESSURE DEW POINT VIA AFTER-COOLER AND AIR DRYER. | | | | |
| | AFTER COOLER/AIR DRYER UNIT WILL BE MOUNTED ON SKID FOR MOBILITY, WHICH WILL PROVIDE FORKLIFTING ON ALL FOUR SIDES. DRYER SHALL UTILIZE DUAL REGENERATIVE PROCESS WITH ALUMINA DESICCANT FOR CONTINUOUS AND AUTOMATIC OPERATION WITH LESS THAN 4 PSIG PRESSURE DROP TO THE BLASTER. MUST BE CONNECTED VIA QUICK-CONNECT HOSE SYSTEM TO COMPRESSOR AND BLASTER. MUST PROVIDE VISUAL DEW POINT INDICATION AND AUDIBLE ALARM WHEN OUTSIDE OF GIVEN PARAMETER. PROVIDE A HEAT EXCHANGER FOR BLASTER WARM AIR, VIBRATION ABSORBER, AIR COOLED AFTER/COOLER AND PARTICULATE AFTER FILTER WITH DIFFERENTIAL PRESSURE GUAGE. AFTER-COOLER CONTROLS TO OPERATE OFF OF ELECTRICAL POWER PROVIDED A 10 KW AIR COOLED DIESEL GENERATOR MOUNTED ON THE SAME SKID AND OPERATING AT 120/240 VOLTS AC FOR 10 HOURS OPERATION AT 50% LOAD. PROVIDE 12 VOLT DC START AND CHARGER. LOW OIL SHUTDOWN. | | | | |

Exception to SF 36
Approved by NARS 7/76

| STANDARD FORM 36, JULY 1966 GENERAL SERVICES ADMINISTRATION FED. PROC. REG. (41 CFR) 1-16.101 | CONTINUATION SHEET | REF. NO. OF DOC. BEING CONT'D N63387-97-RC-4006 | PAGE 3 | OF 4 |
|---|---|---|---|---|

NAME OF OFFEROR OR CONTRACTOR

| ITEM NO | SUPPLIES / SERVICES | QUANTITY | UNIT | UNIT PRICE | AMOUNT |
|---|---|---|---|---|---|

HIGH VOLTAGE BLASTING GUN WILL COME WITH A 45 DEG SWIVEL OR A 45 DEG FIXED HOSE CONNECTION AND BE PROVIDED WITH A (1) SET OF NON-CONDUCTIVE NOZZLES TESTED AND CERTIFIED TO ASTM STANDARD F-711. THE SET WILL INCLUDE THE FOLOWING:

2 EA OF 3 FOOT NOZZLE
2 EA OF 4 FOOT NOZZLE
2 EA OF 6 FOOT NOZZLE
2 EA OF 45 DEG TIP
2 EA OF 90 DEG TIP
2 EA OF STRAIGHT TIP

PROVIDE A ELECTRICAL STATIC ABSORBING FRONT HAND GRIP ON NOZZLES. THE BLASTER SHALL BE CONNECTED TO THE BLAST GUN AND NOZZLE VIA A 75 FOOT BLAST/ICE HOSE ASSEMBLY PROTECTED WITH AN OUTER SHEATH. SHEATH WILL HOLD 1 EACH: HIGH PRESSURE HOSE, SILICONE CO2 PELLET DELIVERY HOSE AND #6 AWG ULTRA FLEXIBLE COPPER STRANDED CLEAR JACKETED CABLE FOR GROUNDING THE BLASTING GUN. HOSE CONNECTIONS SHALL BE FULLY COMPATIBLE WITH THE BLASTING GUN, NON-CONDUCTIVE NOZZLES AND BLASTING UNIT. TO INCLUDE INSTALLATION AND TRAINING OF PERSONNEL.

NOTE: TECHNICAL EVALUATION BY THE REQUESTOR IS REQUIRED PRIOR TO AWARD.
POC: AL JO
TEL: (619) 556-7344

SUGGESTED SOURCE:

ALPHEUS CLEANING TECHNOLOGIES
9119 MILLIKEN AVE
CUCAMONGA, CA 91730
TEL: 1-800-445-6131
FAX: 1-909-980-5696

NOTE: REQUEST CONTRACT ADMINISTRATION BE RETAINED AT FISC, AND PAYMENT OFFICE BE ASSIGNED TO DFAS OAKLAND.

Exception to SF 36
Approved by NARS 9/76

| STANDARD FORM 36, JULY 1966<br>GENERAL SERVICES ADMINISTRATION<br>FED. PROC. REG. (41 CFR) 1-16.101 | CONTINUATION SHEET | REF. NO. OF DOC. BEING CONT'D.<br>N63387- 97-RC-4006 | PAGE<br>4 | OF<br>4 |
|---|---|---|---|---|

NAME OF OFFEROR OR CONTRACTOR

| ITEM NO. | SUPPLIES / SERVICES | QUANTITY | UNIT | UNIT PRICE | AMOUNT |
|---|---|---|---|---|---|

F. O. B. DESTINATION

COST OF PRODUCT TO INCLUDE ALL SHIPPING CHARGES TO CONSIGNEE, DELIVERY POINT AS REQUIRED BY NAVY INDUSTRIAL FUND COST SYSTEM.

"TRUCK DELIVERY ONLY"
"NO RAIL DELIVERIES"

STANDARD STOCK MATERIAL

NOT APPLICABLE/IDENTIFIABLE TO END USE REQUIREMENTS.

DISTRIBUTION OF CONTRACT:

REQUEST THREE (3) COPIES OF CONTRACT TO BE FOWARDED TO:
NAVY PUBLIC WORKS CENTER CODE 840
BOX 368113 BLDG. 3213
2730 McKEAN STREET, SUITE 1
SAN DIEGO, CA 92136-5294
ATTN: RESTY ELEFANTE

DELIVER TO:
NAVY PUBLIC WORKS CENTER
B-3519, NAVAL STATION GATE 9
EIGHTH STREET AND HARBOR DRIVE
NATIONAL CITY, CA.

INVOICES TO BE SUBMITTED TO:

TO BE SPECIFIED ON CONTRACT

PAYMENT TO BE MADE BY:

TO BE SPECIFIED ON CONTRACT

ENCLOSURE 1: PERSONNEL ACCESS LIST

NAVY PUBLIC WORKS CENTER, SAN DIEGO
REQUEST FOR CONTRACTURAL PROCUREMENT NUMBER
PERSONNEL ACCESS LIST:

N63387-97-RC-4006

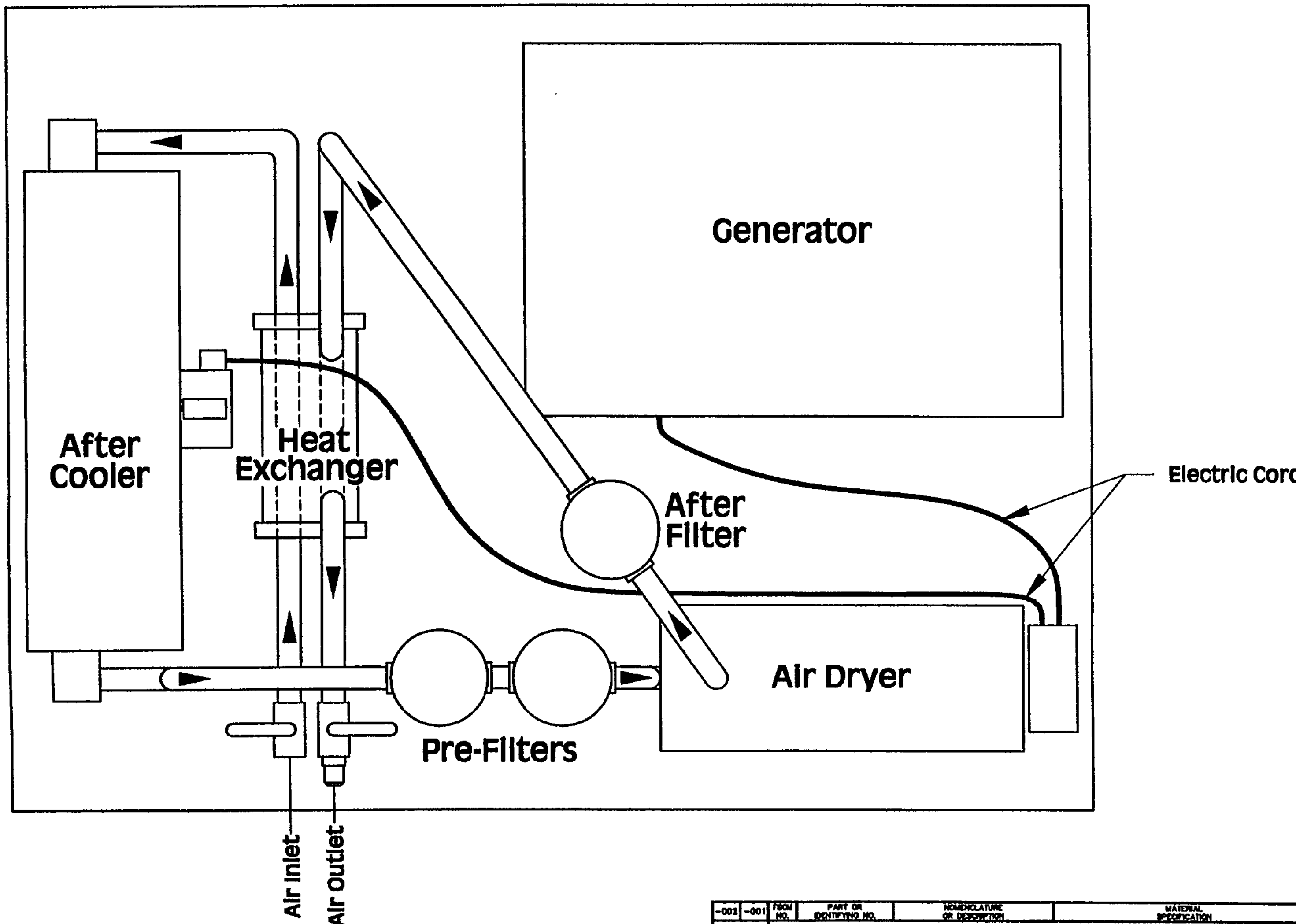
| | |
|---|---|
| JESSE BERMUDEZ | PURCHASING SUPERVISOR |
| RESTY ELEFANTE | REQUIRING ACTIVITIES CONTRACT ADMINISTRATOR (RACA) |
| JIM CONLEY | PROCUREMENT ANALYST |
| BOBBY MCGILL | SUPPLY MANAGEMENT OFFICER |
| AL JO | ENGINEERING TECHNICIAN |

ENCLOSURE (1)

## APPENDIX B

### $C0_2$ SYSTEM HARDWARE MANUAL EXCERPTS

- **Navy Dryer Skid Mounted Components**
- **$CO_2$ Blaster/Mixer, Alpheus MiniBlast Model PLT-5HV.**
- **Air Compressor, Sulair, Model 300H, 80-150 psi at 300 CFM.**
- **After Cooler/Air Dryer & Filter, Domnick Hunter, PNUEDRI; with Dew Point Indicator, Model 8097; and ZEKS Air Dryer Corp, Model 301ACHA540; and API-Ketema, Inc., Heat Exchanger, Shell and Tube type, size 5-Y-18, 200psig, $300^0$ F.**
- **Diesel Electrical Generator, Acme Motori, Model ADX 740, 10KW, 120/240 Volt Duplex.**




| -002 | -001 | FSCM NO. | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MATERIAL SPECIFICATION | ITEM NO. |
|---|---|---|---|---|---|---|
| QTY REQD | | | | PARTS LIST | | |

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: FRACTIONS ± 1/16; DECIMALS .XX ± .03, .XXX ± .010; ANGLES ± 3°

MATERIAL

FINISH

DO NOT SCALE DRAWING

CONTRACT NO.

| APPROVALS | | DATE |
|---|---|---|
| DRAWN | J. LONDENBERG | 12/9/97 |
| CHECKED | | |
| ISSUED | | |

ALPHEUS Cleaning Technologies — RANCHO CUCAMONGA, CALIFORNIA

**Navy Dryer Skid**

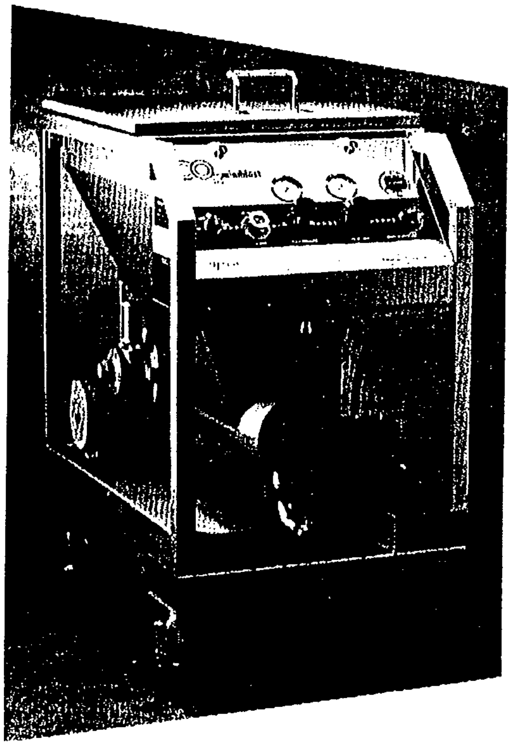
SIZE C | FSCM NO. | DWG NO. navyds.dwg | REV. —

SCALE | SHEET OF

CO2

# MiniBlast™

## Model PLT-5HV



# USER'S GUIDE

ALPHEUS Cleaning Technologies

12308-002
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ALPHEUS Cleaning Technologies

## SYSTEM I.D.

This manual is written for the following system model and serial number which is also displayed on the identification tag permanently attached to the machine.

Model No.: PLT-5 Part No: 13251-001

Serial No: ______________ Customer: ______________

This equipment is covered by one or more of the following patents:

US 4,038,786
US 4,389,820
US 5,071,289
US 5,203,794
US 5,249,426
Australia 491645
Canada 1027760
France 752534
Great Britain 1468495
West Germany 25430197
Italy 1044625
Norway 152778
Sweden PVB413380

This manual contains proprietary information and is solely for the use of the original consignee. It may not be copied or disclosed to any other party.

Alpheus Q.C. Acceptance: ____________ Date: ____________

ALPHEUS Cleaning Technologies

## CAUTIONS & WARNINGS

**Authorization For Use**

Do not operate this system without proper training and authorization from your supervisor. Read and understand the contents of this User's Guide before beginning work.

**Protective Gear**

Make sure you have proper personal protective gear for your job. This gear always includes safety goggles, ear plugs and/or muffs, gloves, and long sleeved clothing. You may also need special clothing, jumpsuits, skin protectors, cartridge respirator, self contained breathing apparatus or other equipment suitable for protection against the risks associated with your particular process or materials.

**Asphyxiation Hazard**

Sublimation of dry ice, whether during blasting or natural warming, forms CO2 gas which may displace oxygen in low lying areas and enclosed spaces. Beware of entering these areas unless you are sure adequate ventilation has been provided. Adequate ventilation is necessary during blasting. Using contaminated compressed air (CO for example) or nitrogen as propellant may greatly increase the respiratory risk. Be sure to use appropriate monitoring equipment for your application. High CO2 indicator will usually suffice in the absence of CO.

**Static Discharge**

Because of high speed particle and air flows, static electricity may build up on different parts and discharge suddenly to the ground or the operator. To minimize static, make sure the equipment and work piece are well-grounded. Provide adequate footing and restraint for the operator to prevent secondary falls.

**BEWARE!** ***Static discharge may ignite flammables.***

**High Speed Pellets**

High speed pellets exiting the gun may cause serious injury. Do not aim the gun at yourself or others. Do not check for pellet flow by using your hand, foot or other body part.



ALPHEUS Cleaning Technologies

**Burn Hazard**

Solid $CO_2$ is very cold (-110° F) and quickly causes deep severe tissue burns on contact with skin. Do not handle $CO_2$ or cold equipment without proper insulating gloves.

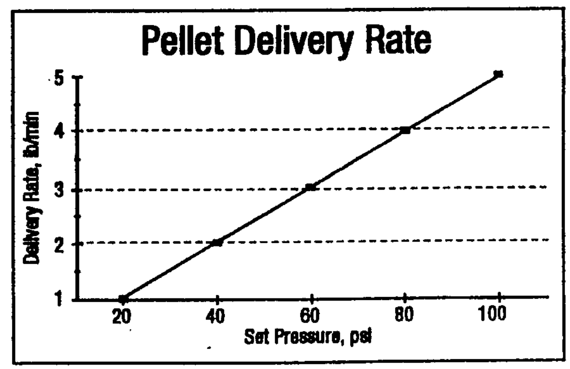
**Pneumatic Stored Energy Hazard**

The control circuitry of this machine may trap air in and between devices. Vent machine before servicing to prevent accidental release of trapped air.

## AIR REQUIREMENTS/FLOW SELECTION

The PLT-5 should be supplied with clean dry air (or gaseous nitrogen). The high pressure air supply should be designed to provide approximately 175 SCFM to the blast nozzle, plus 45 SCFM (corrected to 60 psi) for operation of the machine itself. Use of air that contains excessive water, rust, oil or other contamination will cause plugging of the inlet filter. A secondary filter is provided to protect the pneumatic logic.

***CAUTION: Maximum inlet pressure is 300 psi. Some guns have maximum pressures of 75 psi. Maximum inlet air temperature is 175°F.***



# OPERATING INSTRUCTIONS

1) Familiarize yourself with this instruction manual before use.

2) Obtain training, authorization for use and appropriate protective gear from your supervisor before use.

## START-UP

1) Hook-up air supply, gun, and trigger lines to machine.

2) Turn VENT/RUN selector to 'RUN', turn the RUN/EMPTY HOPPER selector to 'RUN', push E-STOP to 'OFF'. Turn on the air supply. Check for leaks and damaged hoses.

3) Hook-up retractable wire ground to a good earth ground. Ground the workpiece if static discharge is of concern. Clamp small parts securely.

4) **Add $CO_2$ pellets to hopper. Screen or sift out large chunks, if any** (1/2" maximum). Make sure safety grid is in place and interlock spring is compressed. The system is designed to be inoperable unless the safety grid is properly positioned.

5) Check instrument air pressure. It must be 75-90 psi for the blast air actuator to operate properly.

6) Set blast pressure and $CO_2$ **pellet feed rate. Blast pressure must be** at least 20 psi or machine will not run. Check transport air pressure. It must be 60-70 psi and airlock motor pressure about 50 psi.

7) Pull the E-STOP button to the 'ON' position. Push the ARM/RESET button. The blast gun trigger is now armed and blasting can begin.

8) **For maximum blast air pressure, close the regulator back flow valve,** VY, and open the regulator by-pass valve, VX, (see pneumatic schematic). In the regulator by-pass mode correct blast pressure will be shown on the gauge only when blast air is flowing. In addition, please note that with the valves set in this position, blast air is not filtered. Reverse the procedure (close VX and open VY) to return to regulated blast air pressure control.



9) Note that any time after control air is interrupted (by removing the grid or pushing the E-STOP) the ARM/RESET button must be pushed in order to resume machine operation.

**The $CO_2$ pellet rate is independent** of blast pressure. $CO_2$ is approximately **proportional** to auger pitch and air motor speed. Air pressure supplied to the air motor is a good predictor of pellet flow. Pellet flow is approximately one pound per minute per 20 psi supplied to the motor (60 psi is approximately 3 pounds per minute). Pellet flow also depends on pellet size, condition, humidity, hose length, and other factors. You may wish to measure/calibrate your actual flow rate. Theapproximate flow vs. pressure relationship is shown in the graph on page 4.

10) **The elapsed time meter measures** total trigger time. Battery life is approximately 5 years. Replace the meter when battery life is gone.

11) To **start, squeeze gun trigger.** Complete blast cleaning process and release gun trigger.

## STOP / SHUT DOWN

1) Release gun trigger.

2) Push E-STOP to 'OFF' to lock out the trigger.

3) **For extended storage, empty** the pellets from the hopper. First, remove coupling between airlock & pellet feed outlet. Place a suitable diverter in the gap to direct pellets into a container. Select the 'EMPTY' position on the RUN/EMPTY switch. Pellets will come out through the auger tube and may be saved for future use by catching and storing them in an insulated container.

4) **Turn off the air supply at the source.** To bleed off the high pressure **air in the supply hoses and air lines,** select the 'VENT' position on the **VENT/RUN switch. After the air has finished venting,** the input **and output hoses may be disconnected.**

## MAINTENANCE INSTRUCTIONS

1) Check the two gear reducers oil level periodically. Add SAE 140W gear lubricant if needed. Don't fill above the indicated mark (plug painted red) because leakage and overheating may occur.

2) The oilers for the air motors must be filled with a detergent SAE #10 motor oil.

3) The oilers should be adjusted to feed approximately 1 drop per 2 minutes at 100 psi and about 1 drop per 3 minutes at 40 psi.

4) Every 100 hours disassemble, clean and re-lube the hammer with a very thin film of automatic transmission fluid. Excessive lubrication, dirt and foreign material may render the hammer weak or inoperative.

5) Every 5 years replace the elapsed time meter.

6) Clean or replace filters as necessary. Frequency of service will vary greatly based on the cleanliness of the supplied air or nitrogen.

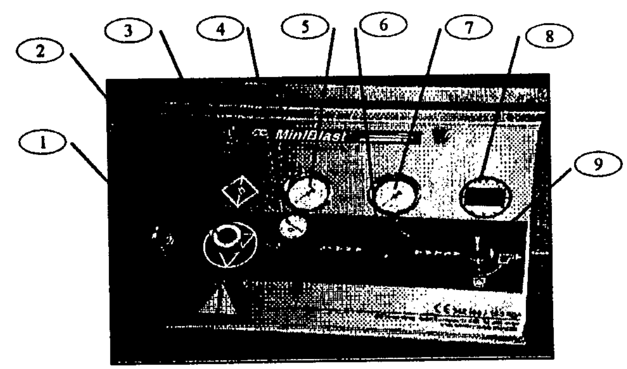
7) Maintain a thin coat of low temperature grease (such as Dow-Corning 33) on the o-ring and mating surfaces of the gun barrel to insure ease of assembly and freedom from binding. Every 100 hours, disassemble the air motor muffler, inspect for contamination, and replace as necessary. If the motor is sluggish, flush the motor with solvent and re-lubricate it. Every 2000 hours or once a year change the Airlock teflon bearing strip.



## CONTROL PANEL DEFINITIONS

1. VENT/RUN switch.
   VENT: Bleeds air system.
   RUN: Pressurizes air system.

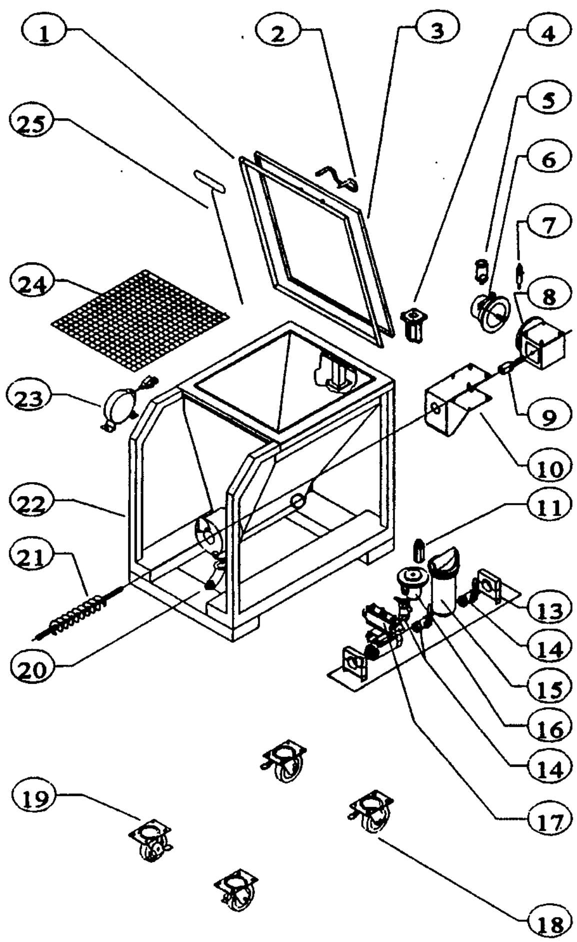
   E-STOP switch.
   ON: Enables controls.
   OFF: Pauses machine, disables controls.
3. ARM/RESET button.
4. BLAST AIR PRESSURE control regulator.
   2 Decrease pressure. 1 Increase pressure.
5. BLAST AIR PRESSURE gauge.
6. $CO_2$ PELLET RATE control regulator.
   2 Decrease pressure. 1 Increase pressure.
7. $CO_2$ PELLET RATE gauge.
8. ELAPSED TIME meter.
9. RUN/EMPTY switch.
   RUN: 'Blasting' position.
   EMPTY: 'Empty the Hopper' position.



| SYMPTOM | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **The unit will not start** | E-STOP switch is in "OFF" position | Pull out the E-STOP switch to "ON" position |
| | VENT/RUN switch is in "VENT" position | Rotate VENT/RUN switch to "RUN" position |
| | The grid is not installed | Install grid to properly depress the grid valve. |
| | Interlock switch is not depressed | Depress switch |
| | Instrument pressure is low | Raise instrument pressure to 75-90 psig |
| | ARM/RESET button has not been pressed | Press ARM/RESET button |
| **The auger mtor does not rotate** | Motor pressure is lower than 20 psig | Raise motor pressure |
| | Instrument air pressure is lower than the pressure on the motor line | Raise instrument air pressure to 75 psig minimum |
| **Blast pressure drops when trigger is pulled regardless of inlet pressure** | Inline filter element (item 12, Cart Assembly) is dirty or plugged | Replace filter element |



| SYMPTOM | PROBABLE CAUSE | REMEDY |
|---|---|---|
| **Hammer does not strike** | Low instrument air pressure | Increase instrument air pressure |
| | Hammer is sticking inside the housing | Disassemble hammer, clean the insert, lubricate with very thin coating of automatic transmission fluid. Remove excess lubricant, clean, and reassemble |
| **The unit works in EMPTY HOPPER mode but does not start in RUN mode** | Low blast pressure | Blast pressure must be set no lower than 20 psi |
| | Low instrument air pressure | Intrument air pressure must be at least 75-80 psi |
| | Improper connections or leak in the trigger lines | Check the trigger lines |
| **Pellet flow is interrupted with auger turning** | Kinked hose | Relieve kink in hose then check for leaks |
| **Pellet flow is interrupted after extended blasting** | Ice formation in suction port. Airlock inlet plugged with chunk of pellets | Press E-STOP button to disable auger. Open flapper and clear any ice that has accumulated in the suction port or airlock inlet |



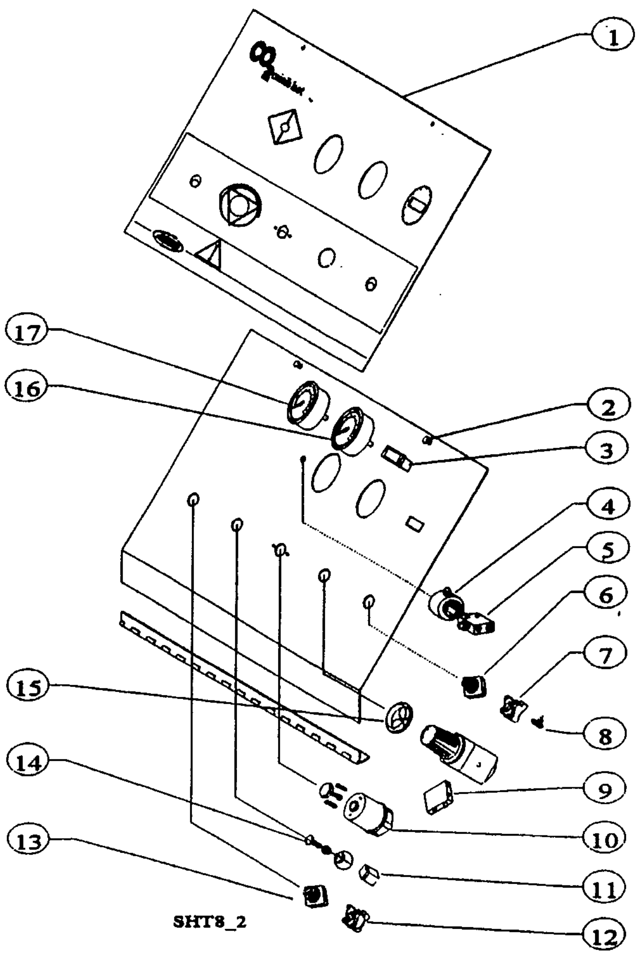

SHT6E

## CART ASSEMBLY



## Cart Assembly Parts List

| Item | Part # | Description | Qty. |
|---|---|---|---|
| 1 | 70211-002 | lid gasket | 8 ft. |
| 2 | 12343-001 | handle | 1 |
| 3 | 12340-001 | cover/lid | 1 |
| 4 | 12326-001 | hammer | 1 |
| 5 | 80123-002 | muffler | 1 |
| 6 | 70337-001 | air motor | 1 |
| 7 | 70341-001 | oiler | 1 |
| 8 | 70338-001 | gear reducer | 1 |
| 9 | 12324-001 | coupler shaft | 1 |
| 10 | 12323-001 | motor bracket | 1 |
| 11 | 70233-008 | in-line filter | 1 |
| 13 | 12371-001 | pipe clamp | 2 |
| 14 | 70070-004 | shut-off valve | 3 |
| 15 | 70233-002 | filter | 1 |
| 16 | 70193-001 | air pressure regulator | 1 |
| 17 | 70080-B01 | ball valve with actuator | 1 |
| 18 | 70139-008 | caster, w/lock | 2 |
| 19 | 70139-007 | caster, w/brake | 2 |
| 20 | 12394-001 | pellet discharge | 1 |
| 21 | 12320-001 | auger | 1 |
| 22 | 12330-001 | cart assembly | 1 |
| 23 | 70198-002 | grounding cable reel | 1 |
| 24 | 12321-002 | grid | 1 |
| 25 | 12325-001 | poker | 1 |

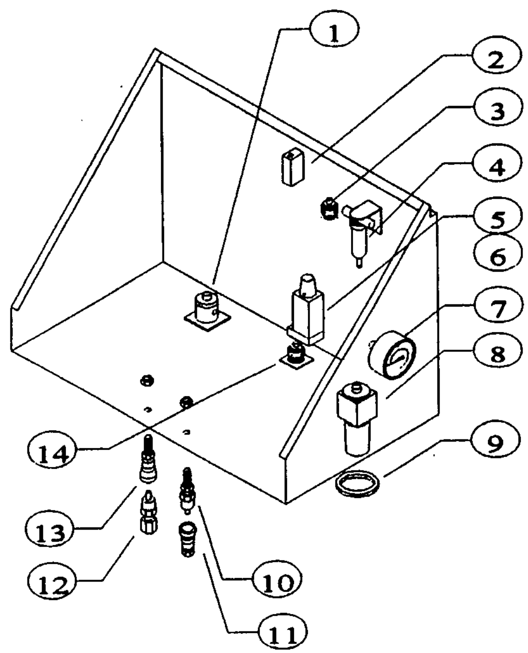



FRONT PANEL CONTROLS



## Front Panel Controls

| Item | Part # | Description | Qty. |
|---|---|---|---|
| 1 | 12382-001 | front panel overlay | 1 |
| 2 | 70104-005 | latch | 2 |
| 3 | 70077-004 | elapsed time indicator | 1 |
| 4 | 70335-008 | valve, poppet (detented) | 1 |
| 5 | 70339-003 | valve, 3-way control/reset | 1 |
| 6 | 70343-001 | selector switch | 2 |
| 7 | 70343-002 | valve, 4-way | 2 |
| 8 | 70366-001 | valve, shuttle | 1 |
| 9 | 70234-006 | air regulator | 2 |
| 10 | 70353-001 | pilot operated check valve | 1 |
| 11 | 70069-001 | pilot regulator | 1 |
| 12 | 70343-004 | valve, stop 3-way | 1 |
| 13 | 70343-003 | stop mushroom | 1 |
| 14 | 70234-008 | mounting nut | 2 |
| 15 | 70350-001 | hinge | 1 |
| 16 | 12384-002 | pressure gauge - 160 psi | 1 |
| 17 | 12384-003 | pressure gauge - 400 psi | 1 |




SHT5 B

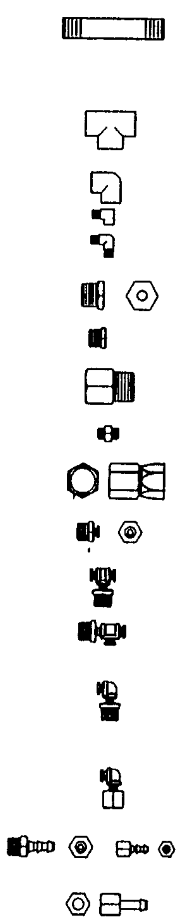
## CONTROL BOX-INTERNAL PARTS



## Control Box Parts List

| Item | Part # | Description | Qty. |
|---|---|---|---|
| 1 | 70335-002 | valve, poppet (air motor) | 1 |
| 2 | 70339-001 | valve, grid limit | 1 |
| 3 | 70335-004 | valve, poppet | 1 |
| 4 | 70233-004 | air filter | 1 |
| 5 | 70342-001 | pulse generator | 1 |
| 6 | 70342-002 | mounting block for pulse generator | 1 |
| 7 | 12384-001 | pressure gauge, 100 psi | 1 |
| 8 | 70234-006 | air regulator | 2 |
| 9 | 70234-008 | mounting nut | 2 |
| 10 | 70346-003 | connector, male bulkhead | 1 |
| 11 | 70346-004 | connector, female | 1 |
| 12 | 70346-002 | connector, male | 1 |
| 13 | 70346-001 | connector, female bulkhead | 1 |
| 14 | 70335-003 | valve,poppet (hammer) | 2 |

ALPHEUS Cleaning Technologies



PIPE NIPPLES

| | |
|---|---|
| 80010-221 | 1" CLOSE |
| 80010-223 | 1" X 2" |
| 80010-226 | 1" X 3½" |
| 80010-229 | 1" X 8" |
| 80011-132 | ¼" X 1½" |
| 80011-142 | ¼" X 6" |
| 80011-111 | ⅛" CLOSE |

PIPE TEES

| | |
|---|---|
| 80013-506 | 1" |
| 70286-B04 | ¼" |
| 80013-B02 | ¼" |

PIPE ELBOWS

| | |
|---|---|
| 80019-008 | 1" FEMALE |
| 80119-B02 | ¼" FEMALE |
| 70021-B04 | ¼" NPT STREET ELBOW |
| 70159-B02 | ⅛" MALE ELBOW |

PIPE BUSHINGS

| | |
|---|---|
| 70212-002 | 1" X ¼" |
| 70354-001 | ¼" X ⅛" |

PIPE ADAPTER

| | |
|---|---|
| 70355-001 | ⅛" X 10-32 UNC |

PIPE CONNECTOR

| | |
|---|---|
| 70249-015 | 1" X ¾" |

MINIATURE NIPPLE

| | |
|---|---|
| 70356-001 | 10-32 UNC |

SWIVEL

| | |
|---|---|
| 70344-016 | 1" X 1" JIC |

PIPE TO TUBE CONNECTORS

| | |
|---|---|
| 70347-018 | ¼"T X ⅛"NPT |
| 70347-019 | ¼"T X ¼"NPT |

PIPE TO TUBE TEE

| | |
|---|---|
| 70347-062 | ¼"T X ⅛"NPT |

MALE RUN TEE

| | |
|---|---|
| 70347-077 | ¼"T X ¼"NPT |

MALE TUBING ELBOWS, SWIVEL

| | |
|---|---|
| 70347-046 | ⅛"T X ⅛"NPT |
| 70347-047 | C |
| 70347-048 | ¼"T X ⅛"NPT |
| 70347-078 | ¼"T X ⅛"NPT, NON-SWIVEL |
| 70347-081 | ¼"T X ¼"NPT, NON-SWIVEL |

FEMALE TUBIN ELBOW

| | |
|---|---|
| 70347-076 | ¼"T X ¼"NPT |

MALE BRASS HOSE FITTINGS

| | |
|---|---|
| 70345-001 | ¼"T X ¼"NPT |
| 70345-003 | ⅛"T X ¼"NPT |

FEMALE BRASS HOSE FITTING

| | |
|---|---|
| 70345-002 | ¼"T X ¼"NPT |

*NOTE:* ITEMS WITHOUT PART NUMBERS ARE NOT SHOWN ON DRAWINGS



ALPHEUS Cleaning Technologies

## PLT-5 Parts List

| Part # | Description | Qty. |
|---|---|---|
| 70178-023 | pressure switch | 1 |
| 70233-003 | auto drain | 1 |
| 80046-001 | whip check | 2 |
| 80105-016 | protective sleeve | 25' |
| 80172-001 | trigger tube, clear | 25' |
| 80172-002 | trigger tube, black | 25' |
| 80174-001 | hairpin-cotter | 1 |
| 12312-001 | hose assembly | 1 |
| 12313-001 | air hose | 1 |
| 12322-001 | hammer gasket | 1 |
| 12328-001 | flapper | 1 |
| 12359-001 | connector, male | 1 |
| 70346-001 | bushing | 1 |
| 12387-001 | push rod | 1 |

*NOTE:* PARTS WITHOUT ITEM NUMBERS ARE NOT SHOWN ON DRAWINGS

## SPECIFICATIONS

| | |
|---|---|
| Dimensions: | 24½" x 36" x 44" (W x L x H) |
| Weight: | 390 lbs. |
| Inlet Air Temperature: | 175° Maximum |
| Inlet Air Pressure: | 300 psi (some guns have a 125 psi maximum) |
| Inlet Air Connector: | 1" NPT |

## Recommended Spare Parts
## $CO_2$ MiniBlast™ Model PLT-5

### Group A (Preventive Maintenance)

| PART # | DESCRIPTION |
|---|---|
| | Silicone Pellet Transport Hose |
| 12411-001 | Valve, Gun Trigger |
| 70233-006 | Element for Air Filter (70233-002) |
| 70233-007 | Element for Small Air Filter (70233-004) |
| 70341-002 | Repair Kit for Air Motor Oiler (70341-001) |

### Group B (Repair)

| PART # | DESCRIPTION |
|---|---|
| 70069-004 | Repair Kit for Pilot Regulator (70069-001) |
| 70193-002 R | Repair Kit Pressure Regulator (70193-001) |
| 70234-010 | Repair Kit for Air Regulator - Instrument or Motor (70234-006) |
| 70335-005 | Repair Kit for Poppet Valve 125A (70335-003) |
| 70335-006 | Repair Kit for Poppet Valve (70335-002) |
| 70335-007 | Repair Kit for Poppet Valve (70335-001) |
| 70233-009 | Repair Kit for Inline Filter (70233-008) |

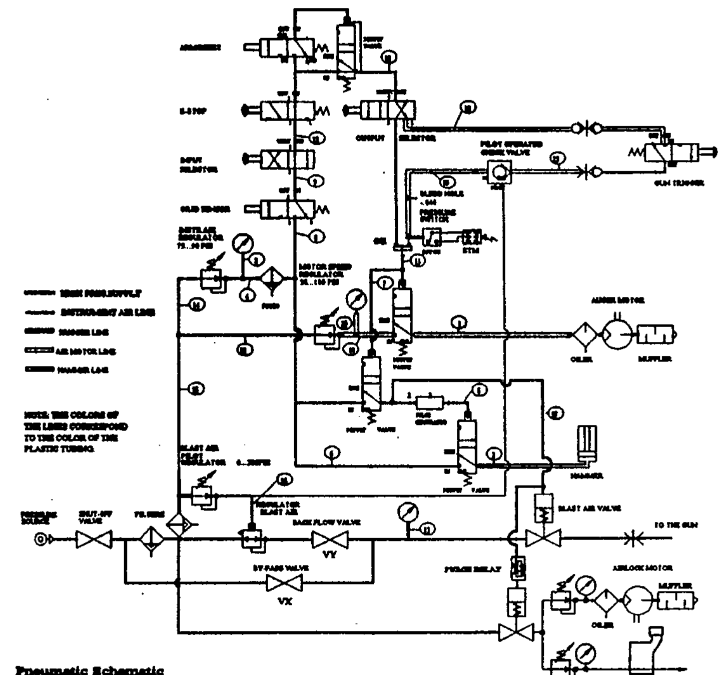
### Group C (Uptime Critical)

| PART # | DESCRIPTION |
|---|---|
| | Blast Hose Assembly |
| 70337-001 | Air Motor |
| 70343-002 | Four Way Valve Selector (Vent/Run) |
| 70366-001 | Shuttle Valve for "OR" Function |

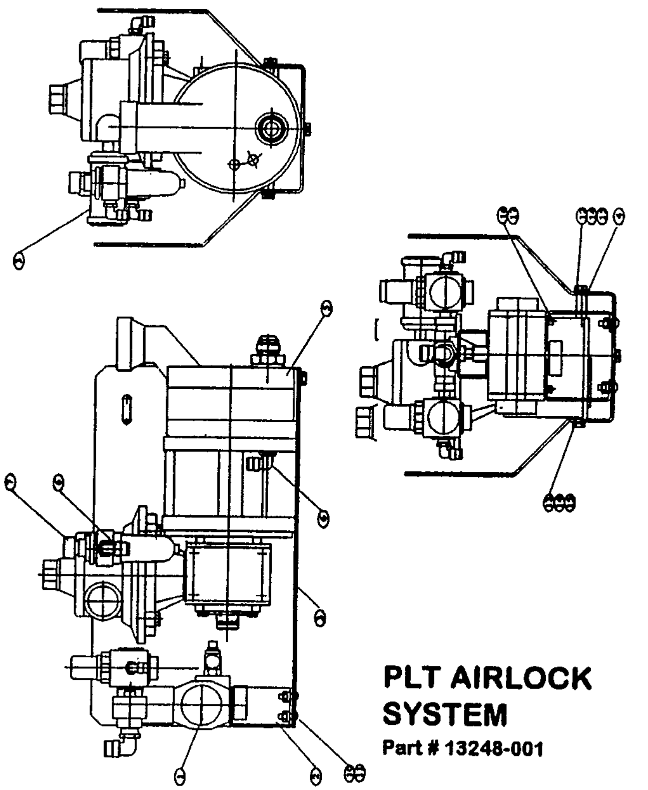
### Group D (Other)

| PART # | DESCRIPTION |
|---|---|
| 12312-003 | SST Blast Hose - High Temperature |
| 70386-000 | Socket Drive Tool |





**Pneumatic Schematic for PLT with airlock Drawing 13263**



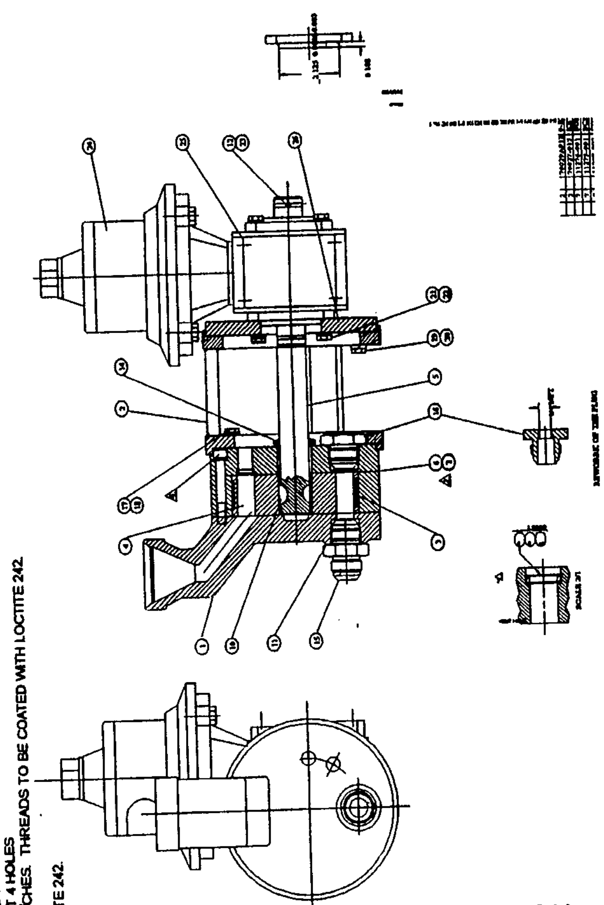
PLT AIRLOCK SYSTEM

Part # 13248-001



## PLT Airlock System Parts List

| Item | Part # | Description | Qty. |
|---|---|---|---|
| 1 | 13253-001 | air supply assembly | 1 |
| 2 | 13247-001 | bracket air system | 1 |
| 3 | 13246-001 | trough airlock | 1 |
| 4 | 11254-001 | spacer | 1 |
| 5 | 13252-001 | airlock assembly | 1 |
| 6 | 79418-010 | elbow swivel ¼" | 1 |
| 7 | 70341-001 | oiler | 2 |
| 8 | 80123-002 | muffler ¼" | 4 |
| 9 | 80011-133 | nipple ¼"x2.0 | 4 |
| 10 | 80055-004 | locknut ¼" | 2 |
| 11 | 80039-312 | button hd screw | 2 |
| 12 | 80034-014 | hex hd screw 5/16-18x5/8 | 2 |
| 13 | 80034-005 | hex hd screw 5/16-18x1.75 | 4 |
| 14 | 80063-009 | lockwasher 5/16 | 1 |
| 15 | 80077-012 | washer 5/16 | 1 |
| 16 | 80086-002 | socket hd screw | 1 |
| 17 | 80063-006 | lockwasher #10 | 4 |



NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL PARTS SHALL BE THOROUGHLY CLEANED PRIOR TO ASSEMBLY.
2. USE ITEMS 8 AND 9 TO ESTABLISH .0005/.0015 END CLEARANCE BETWEEN ITEM 2 ROTOR AND ITEM 4 END CAP
3. INSTALL ITEMS 8, 9 AND 13 AT 4 HOLES
4. TORQUE BOLTS TO 113 LB-INCHES. THREADS TO BE COATED WITH LOCTITE 242.
5. INSTALL ITEM 14 ON ITEM 3.
6. COAT THREADS WITH LOCTITE 242.

## PLT AIRLOCK ASSEMBLY

**Part # 13252-001**



## PLT Airlock Assembly Parts List

| Item | Part # | Description | Qty. |
|---|---|---|---|
| 1 | 12005-001 | housing assembly | 1 |
| 2 | 11070-001 | bracket assembly | 1 |
| 3 | 11075-001 | bearing | 1 |
| 4 | 11724-001 | rotor | 1 |
| 5 | 13244-001 | shaft | 1 |
| 6 | 11207-001 | shim - airlock | 1 |
| 7 | 11207-002 | shim - airlock | 2 |
| 8 | 11275-001 | screen vent | 4 |
| 9 | 11276-001 | support screen | 4 |
| 10 | 70027-015 | key woodruff | 2 |
| 11 | 70029A912 | o-ring | 2 |
| 12 | 80027-G04 | set screw | 2 |
| 13 | 70040-062 | retaining ring | 4 |
| 14 | 70045-057 | v ring | 1 |
| 15 | 70050-S09 | union large hex | 1 |
| 16 | 70530-S01 | plug, JIC ¾" | 1 |
| 17 | 80035-010 | screw hex head | 4 |
| 18 | 80063-010 | lockwasher 3/8" | 4 |
| 19 | 80034-008 | hex hd screw | 4 |
| 20 | 80063-009 | lockwasher 5/16" | 4 |
| 21 | 80043-008 | hex hd screw | 4 |
| 22 | 80063-008 | lockwasher ¼" | 4 |
| 23 | 12327-001 | key 3/16 square | 1 |
| 24 | 70337-001 | air motor | 1 |
| 25 | 70338-003 | gear reducer | 1 |
| 26 | 13245-001 | flange | 1 |

SULLAIR®

# PORTABLE
# AIR COMPRESSOR
# 300H, 375, 375H & 425 DPQ
## JOHN DEERE

## OPERATOR'S MANUAL AND PARTS LIST

**KEEP FOR FUTURE REFERENCE**

Part Number 02250096–922

Section 2
# DESCRIPTION

## 2.1 INTRODUCTION

The Sullair 300H 375. 375H and 425. Portable Air Compressors offer superior performance and reliability while requiring very minimal maintenance.

The compressors are equipped with a Sullair rotary screw compressor unit. Compared to other compressors, the Sullair is unique for its mechanical reliability, performance and durability. The compressor never needs any inspection of the internal parts.

As you continue reading this manual and learn how the compressor operates and is maintained, you will see how surprisingly easy it is to keep a Sullair air compressor in top operating condition.

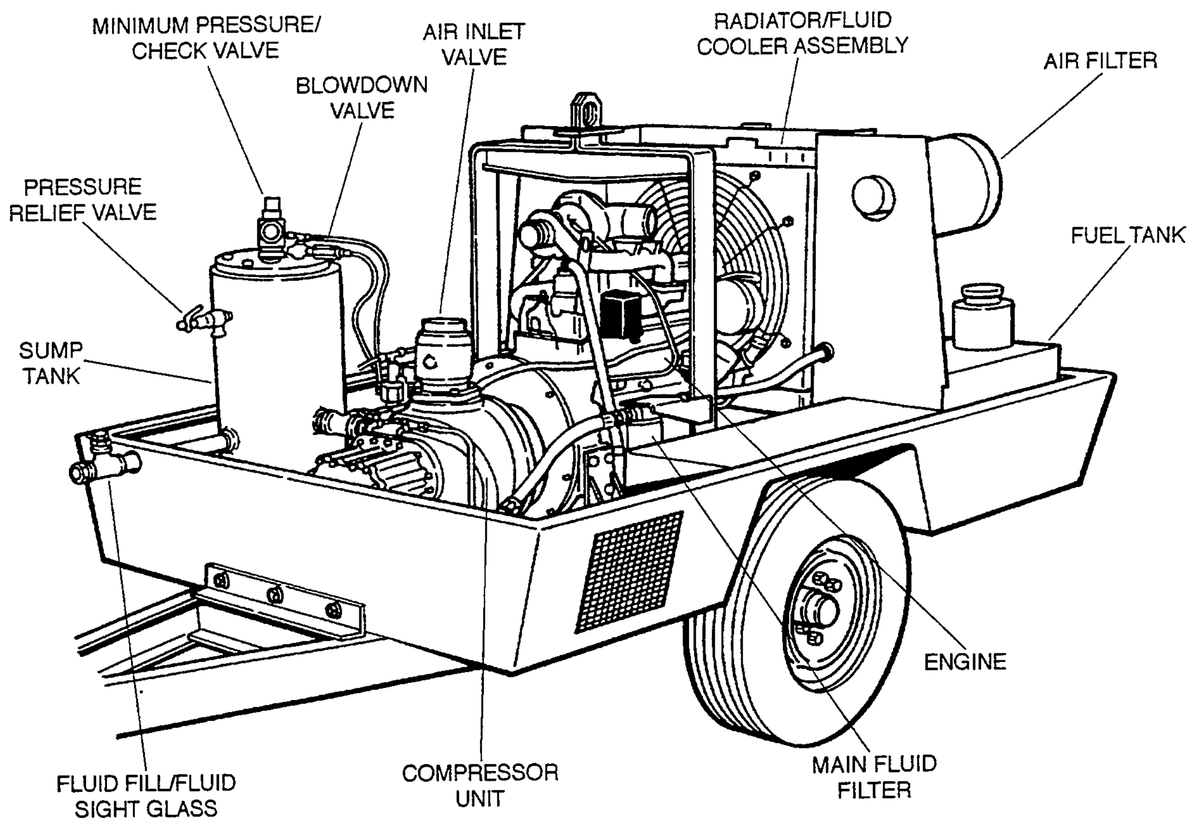
Read Section 5 (Maintenance) to keep your compressor in top operating condition. Should any problem or question arise which cannot be answered in this text, contact your nearest Sullair representative or the Sullair Corporation Service Department.

## 2.2 DESCRIPTION OF COMPONENTS

Refer to Figure 2–1. The components and assemblies of the Sullair 300H, 375, 375H and 425. Air Compressors are clearly shown. The packages include a **compressor unit, diesel engine, compressor inlet system, compressor cooling and lubrication system, compressor discharge system, capacity control system, instrument panel and electrical system.** The compressor is also equipped with sound deadening insulation to lower noise emissions to a comfortable level.

A low profile canopy offers improved handling and mobility. Large side service doors provide easy ac-

*Figure 2–1 Sullair Rotary Screw Portable Air Compressor*



cess to all serviceable components.

The Sullair air compressors are capable of delivering capacities as follows:

| | |
|---|---|
| Model 300H | 300CFM @ 150 PSIG (10.3 bar) |
| Model 375 | 375CFM @ 100 PSIG (6.9 bar) |
| Model 375H | 375CFM @ 150 PSIG (10.3 bar) |
| Model 425 | 425CFM @ 100 PSIG (6.9 bar) |

The control systems can be easily adjusted for pressures from 70 to 125 psig (4.8 to 8.6 bar) for standard machines and from 70 to 150 psig (4.8 to 10.3 bar) for "H" machines. The compressor unit is driven by an industrial engine designed to provide enough horsepower for more than adequte reserve at rated conditions. Refer to the Engine Operator's Manual for a more detailed description of the engine.

The **engine cooling system is comprised of a radiator, high capacity fan, engine fluid cooler and thermostats.** The fan draws air through the radiator, keeping the engine at the proper operating temperature.

The same fan also cools the fluid used in the compressor cooling and lubrication system. Prior to passing through the radiator, the air drawn by the fan passes through the compressor fluid cooler (mounted in front of the radiator). The passage of air through the cooler removes the heat of compression from the fluid.

The engine is coupled to the compressor unit with a rubber element–type coupling. The compressor is supplied with fuel tanks large enough to keep the compressor running at full load through one eight hour shift.

## 2.3 SULLAIR COMPRESSOR UNIT, FUNCTIONAL DESCRIPTION

Sullair compressors feature the Sullair compressor unit, a single–stage, positive displacement, fluid lubricated–type compressor. This unit provides continuous pulse–free compression to meet your needs. With a Sullair compressor, no maintenance or inspection of the internal parts of the compressor unit is permitted in accordance with the warranty.

Fluid is injected into the compressor unit and mixes directly with the air as the rotors turn compressing the air. The fluid has three functions:

1. As coolant, it controls the rise of air temperature normally associated with the heat of compression.
2. Seals the leakage paths between the rotors and the stator and also between the rotors themselves.
3. Acts as a lubricating film between the rotors allowing one rotor to directly drive the other, which is an idler.

After the air/fluid mixture is discharged from the compressor unit, the fluid is separated from the air. At this time, the air flows to your service line and the fluid is cooled in preparation for reinjection.

## 2.4 COMPRESSOR COOLING AND LUBRICATION SYSTEM, FUNCTIONAL DESCRIPTION

Refer to Figures 2–2 and 2–3. The compressor cooling and lubrication system is designed to provide adequate lubrication as well as maintain the proper operating temperature of the compressor. In addition to the cooler and fan, the **system consists of a main filter,** and a **thermal valve.**

The fluid in the system is used as both coolant and lubricant. It is housed in the receiver/sump or sump (which will be referred to as the SUMP from hereon). Upon start–up, the temperature of the fluid is low thus routing it to the fluid cooler is not necessary. Hence the fluid takes a path of lowest resistance by flowing from the thermal valve to the compressor.

The thermal valve has two entrance ports and one exit port. The entrance ports will be referred to as Port A and Port B. Port A accepts fluid from the sump and Port B accepts fluid from the cooler.

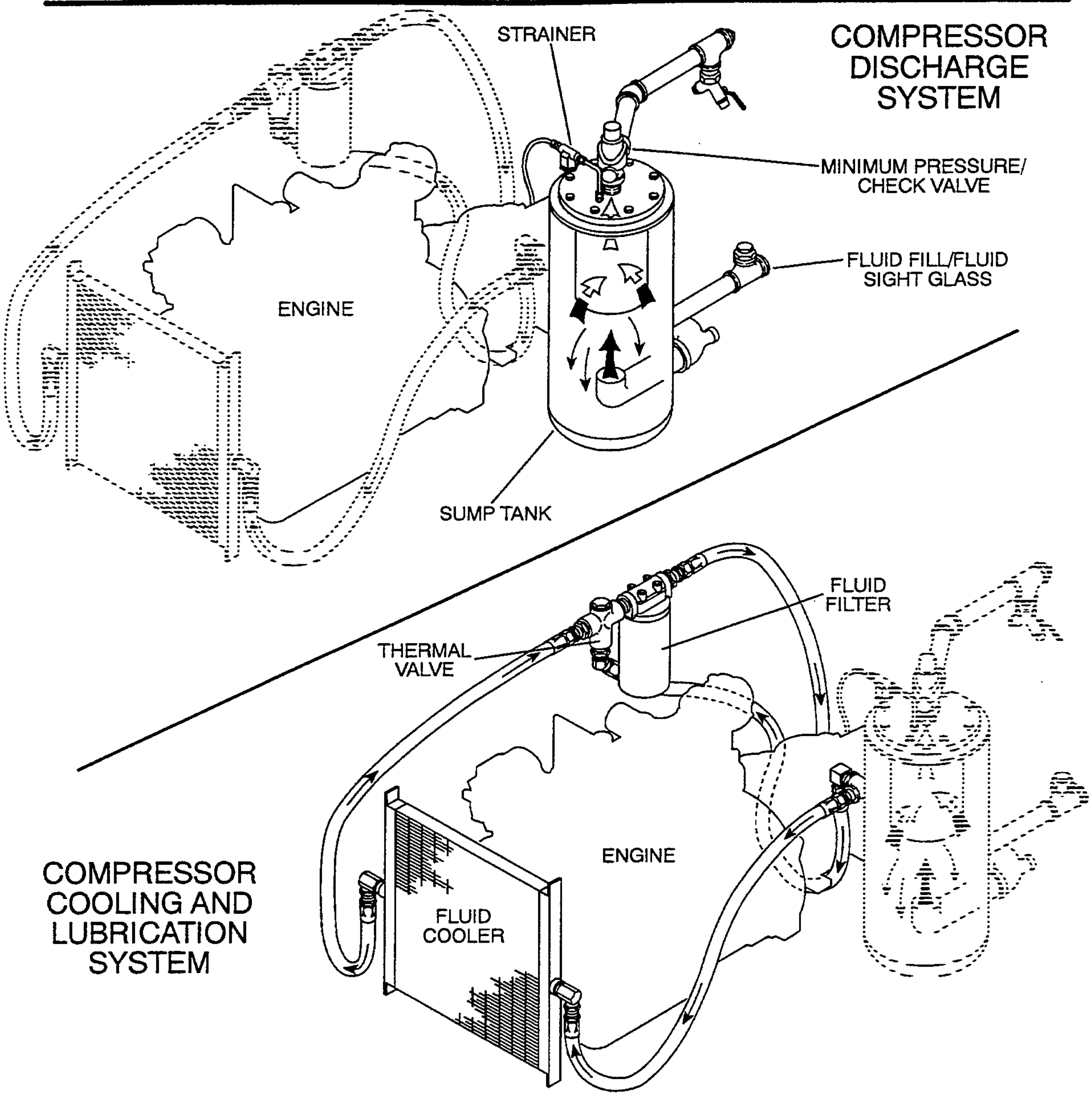
As previously stated, upon start–up the fluid temperature is low and thus it is not routed to the cooler. The fluid first enters the thermal valve and then flows to the compressor unit, bypassing the cooler. As the compressor continues to operate, the temperature of the fluid rises and Port A of the thermal valve begins to close. The closing of Port A forces a portion of the fluid through the fluid cooler.

The cooler is a radiator–type that works in conjunction with the engine fan. The fan draws air through the cooler removing the heat of compression from the fluid. From the cooler, the fluid is routed back to the thermal valve entering at Port B. Before the temperature of the fluid becomes high enough that Port A is completely closed, cooled fluid entering at Port B is mixed with warmer fluid entering at Port A. When the temperature of the fluid reaches 140°F (60°C), Port A is completely closed causing all fluid to flow to the cooler (as shown in Figure 2–3). After the fluid passes through the thermal valve it is then directed through the main fluid filter. There the fluid is filtered in preparation for injection into the compression chamber and bearings of the compressor unit.

The filter has a replaceable spin–on element and a built–in bypass valve which allows the fluid to flow even when the filter element becomes plugged and requires changing or when the viscosity of the fluid is too high for adequate flow. After the fluid is properly filtered, it then flows on to the compressor unit where it lubricates, seals and cools the compression chamber as well as lubricates the bearings and gears.

At shutdown, the pressure signal is lost and the inlet valve closes, isolating the compressor unit from the cooling system.

*Figure 2–2 Compressor Discharge and Cooling and Lubrication System*



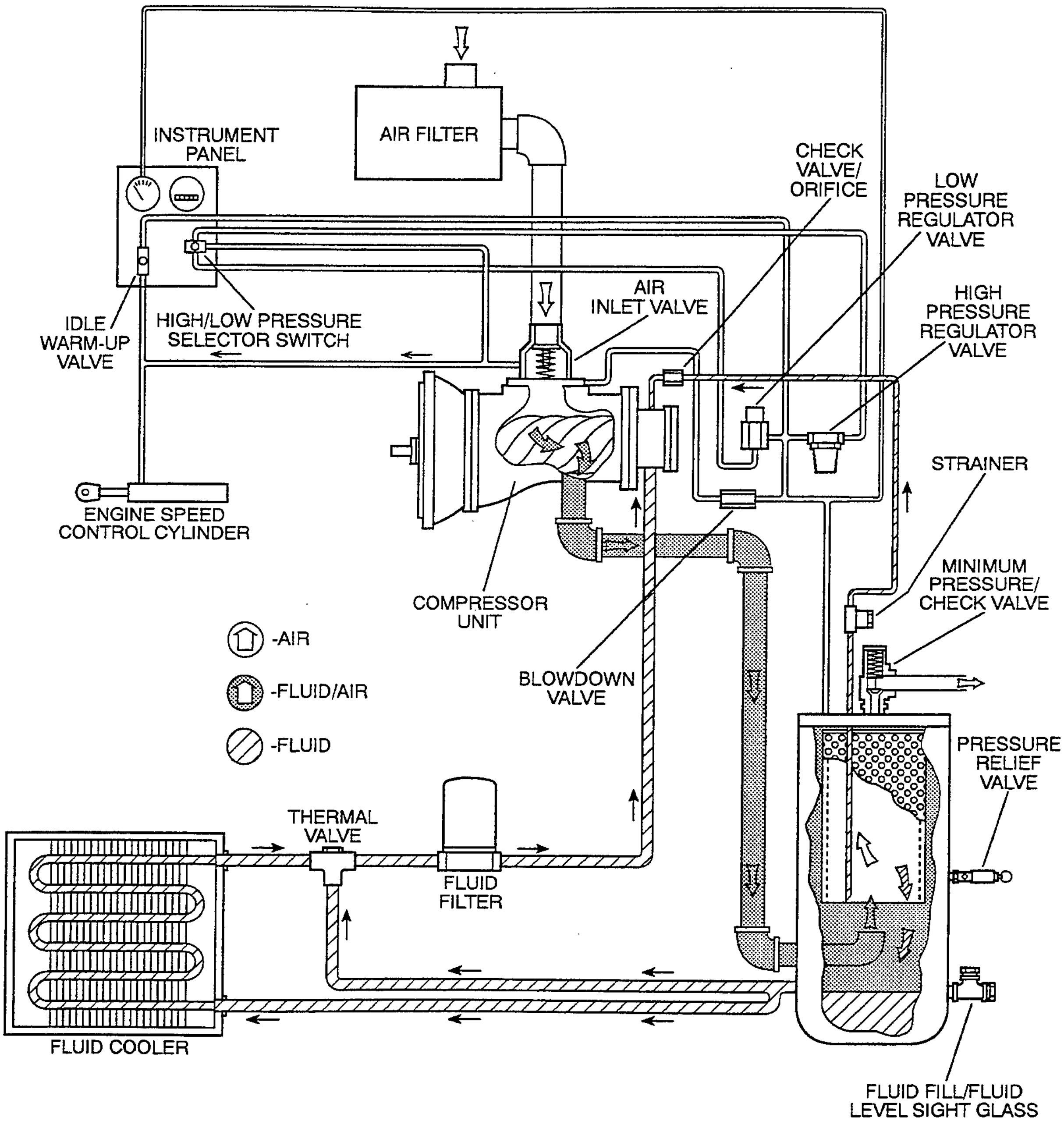

### 2.5 COMPRESSOR DISCHARGE SYSTEM, FUNCTIONAL DESCRIPTION

Refer to Figures 2–2. The Sullair compressor unit discharges compressed air/fluid mixture. The air fluid mixture is directed to the combination sump. The sump has three functions:

1. It acts as a primary fluid separation system.
2. Serves as the compressor fluid sump.
3. Houses the air/fluid separator.

The compressed air/fluid mixture enters the sump and is directed against the side wall. By change of direction and reduction of velocity, larger droplets of fluid separate and fall to the bottom of the sump. The fractional percentage of fluid remaining in the compressed air collects on the surface of the final separator element as the compressed air flows through

*Figure 2–4 Control System 300H and 375H Models*




2.6

# SPECIFICATIONS

*SPECIFICATIONS – **300H, 375, 375H JOHN DEERE***

| Model Series | Length (I) in | Length (I) mm | Width in | Width mm | Height in | Height mm | Weight (wet) lb | Weight (wet) kg |
|---|---|---|---|---|---|---|---|---|
| **300H, 375, 375H 2–Wheel** | **148** | 3759 | **72** | 1829 | **62.5** | 1588 | **4346 *** | 1971 * |
| **300H, 375, 375H, DLQ** | **95** | 2413 | **72** | 1829 | **51** | 1295 | **4091 *** | 1856 * |

(I) Length over drawbar for 2–wheel version.
*For 375H add 1098 lbs. (50 kg).

| COMPRESSOR: | 300H | 375 | 375H |
|---|---|---|---|
| Type | Rotary Screw | Rotary Screw | Rotary Screw |
| Maximum Operating Pressure | 150 psig (10 bar) | 125 psig (8.6 bar) | 150 psig (10 bar) |
| Delivery | 300 Free CFM (142 L/s) | 375 Free CFM (177 L/s) | 375 Free CFM (177 L/s) |
| Rated Pressure | 150 psig (10.3 bar) | 100 psig (7 bar) | 150 psig (10.3 bar) |
| Cooling | Pressurized Compressor Fluid | Pressurized Compressor Fluid | Pressurized Compressor Fluid |
| Lubricating Compressor Fluid | See Table 1 | See Table 1 | See Table 1 |
| Sump Capacity | 7 U.S. gallons (26.5 liters) | 7 U.S. gallons (26.5 liters) | 7 U.S. gallons (26.5 liters) |
| Track Width | 60" (1524mm) | 60" (1524mm) | 60" (1524mm) |
| Tire Size (Load Range) | H78 x 15ST (D) | H78 x 15ST (D) | H78 x 15ST (D) |
| Tire Pressure | 65 psig (4.4 bar) | 65 psig (4.4 bar) | 65 psig (4.4 bar) |
| Wheel Size | 15 x 6JJ | 15 x 6JJ | 15 x 6JJ |
| Lug Nut Torque | 60 ft.–lbs. (81 Nm) | 60 ft.–lbs. (81 Nm) | 60 ft.–lbs. (81 Nm) |
| Operating Tilt (maximum) | 15° | 15° | 15° |
| Electrical System | 12 Volt | 12 Volt | 12 Volt |
| Compressor Discharge Temp. | Shutdown 240° (115°C) | Shutdown 240° (115°C) | Shutdown 240° (115°C) |
| Service Valves | (2) ¾" | (2) ¾" | (2) ¾" |
| Maximum Towing Speed | 55 MPH (88 KMPH) | 55 MPH (88 KMPH) | 55 MPH (88 KMPH) |
| Axle Rating | 5000 pounds (2268 Kg) | 5000 pounds (2268 Kg) | 5000 pounds (2268 Kg) |
| Sound Level | 76 dBA at 7 meters | 76 dBA at 7 meters | 76 dBA at 7 meters |
| **ENGINE:** | | | |
| Type | Diesel | Diesel | Diesel |
| Make | John Deere | John Deere | John Deere |
| Model | JD 4045TF150 | JD 4045TF150 | JD 4045TF250 |
| Displacement | 276 cu. in. (4.5L) | 276 cu. in. (4.5L) | 276 cu. in. (4.5L) |
| Cylinders | 4 | 4 | 4 |
| Bore x Stroke | 4.19 x 5.00 (106mm x 127mm) | 4.19 x 5.00 (106mm x 127mm) | 4.19 x 5.00 (106mm x 127mm) |
| Rated Speed | 2400 RPM | 2400 RPM | 2400 RPM |
| Rated Power | 115HP/86kW | 115HP/86kW | 125HP/93kW |
| Type of Motor Oil | See Engine Operator's Manual | See Engine Operator's Manual | See Engine Operator's Manual |
| Fuel Tank Capacity | 48 gallons (181.7 liters) | 48 gallons (181.7 liters) | 48 gallons (181.7 liters) |
| Radiator Capacity | 8 gallons (30 Liters) | 8 gallons (30 Liters) | 8 gallons (30 Liters) |
| Engine Water Temperature | Shutdown 239°F (115°C) | Shutdown 239°F (115°C) | Shutdown 239°F (115°C) |
| Minimum Idle Speed | 1600 RPM (II) | 1400 RPM (II) | 1600 RPM (II) |
| Alternator Rating | 65 amp | 65 amp | 65 amp |

(II) **DO NOT** allow engine idle rpm to drop below minimum idle speed. Compressor and/or coupling damage will occur.

# *PowerTech* 4.5 L & 6.8 L
# 4045 and 6068
# OEM Diesel Engines

**1996 EPA Certification Levels**
**(U.S.A.)**

# OPERATION AND MAINTENANCE MANUAL

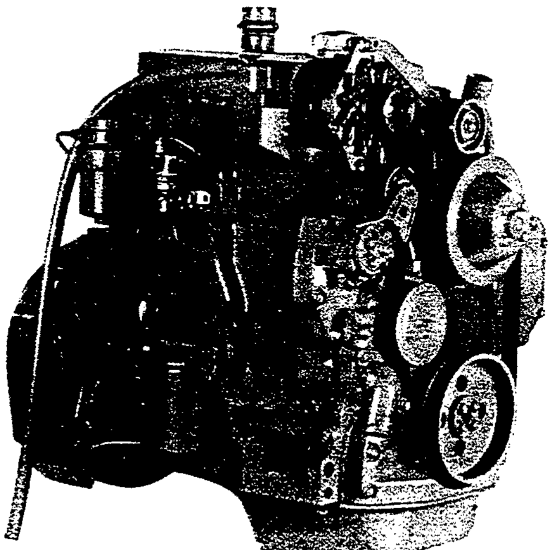
**Deere Power Systems Group**
**OMRG25204 (20MAY96)**
LITHO IN U.S.A.
ENGLISH

JOHN DEERE

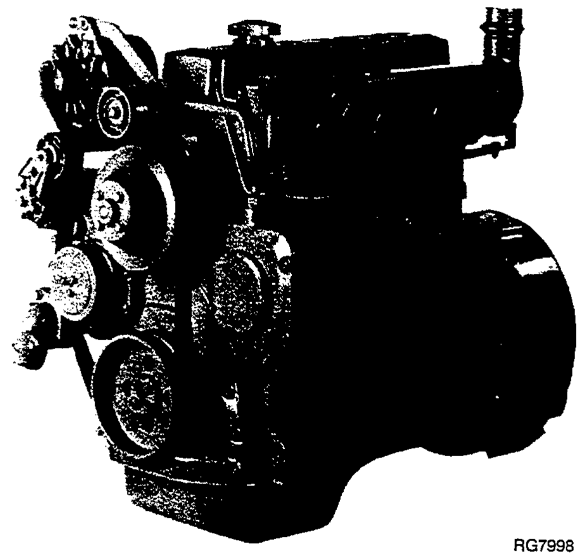
DEERE POWER

# Identification Views

## *PowerTech* 4.5 L ENGINES

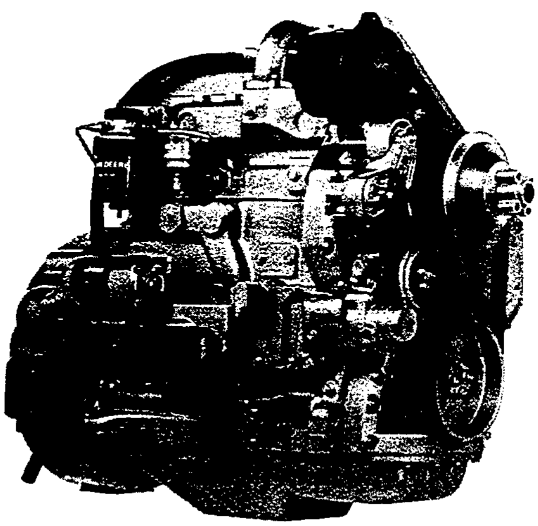


RG7999

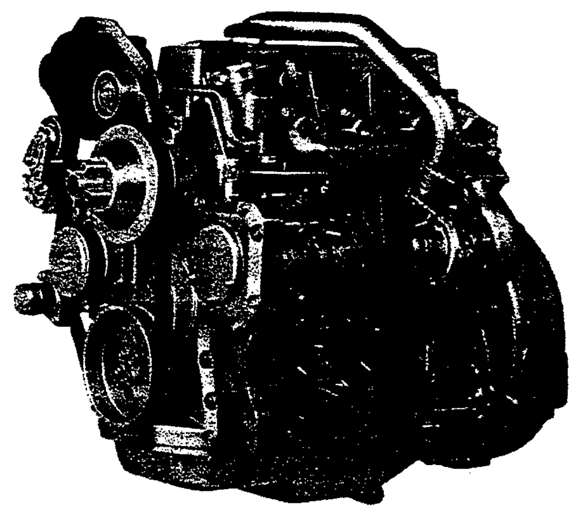


RG7998

*4045D Engine*



RG7996



RG7997

*4045T Engine*

# Specifications

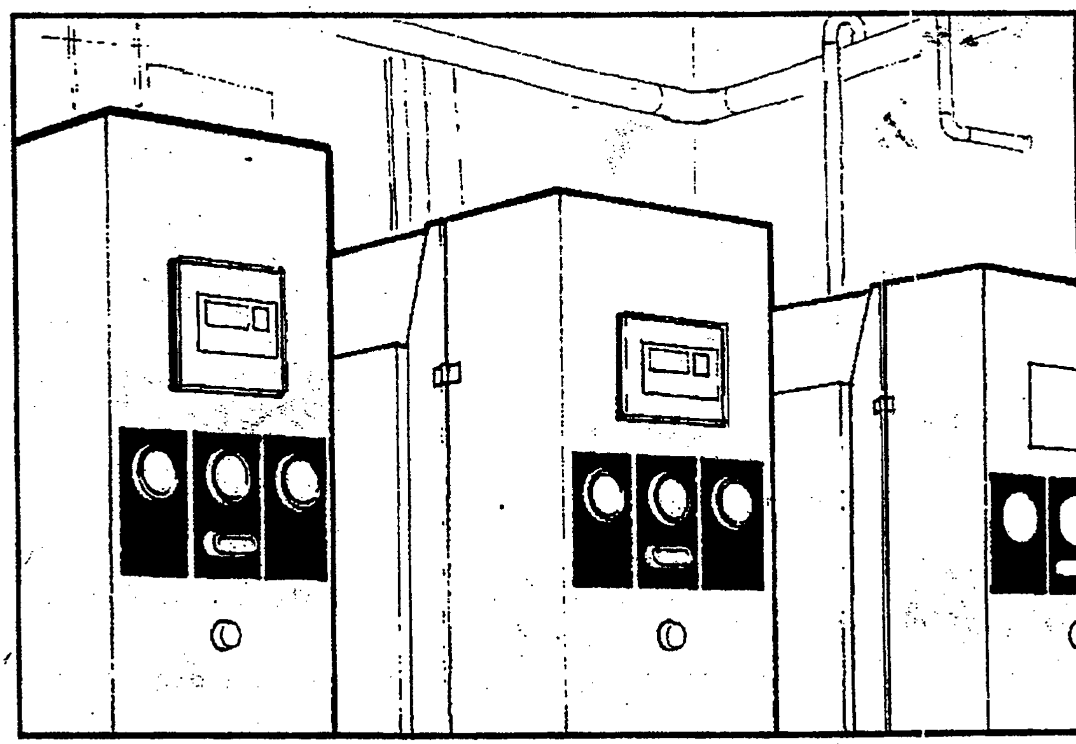
## GENERAL OEM ENGINE SPECIFICATIONS

| ITEM | UNIT OF MEASURE | 4045DF150 | 4045TF150 | 4045TF250 |
|---|---|---|---|---|
| Number of Cylinders | — | 4 | 4 | 4 |
| Fuel | — | Diesel | Diesel | Diesel |
| Bore | mm<br>(in.) | 106<br>(4.19) | 106<br>(4.19) | 106<br>(4.19) |
| Stroke | mm<br>(in.) | 127<br>(5.00) | 127<br>(5.00) | 127<br>(5.00) |
| Displacement | L<br>(cu in.) | 4.5<br>(276) | 4.5<br>(276) | 4.5<br>(276) |
| Compression Ratio | — | 17.6:1 | 17.0:1 | 17.0:1 |
| Physical Dimensions:<br>Width | mm (in.) | 598 (23.5) | 598 (23.5) | 598 (23.5) |
| Height | mm (in.) | 854 (33.6) | 980 (38.6) | 980 (38.6) |
| Length | mm (in.) | 861 (33.9) | 861 (33.9) | 861 (33.9) |
| Basic Dry Weight | kg (lb) | 387 (851) | 396 (872) | 396 (872) |

domnick hunter

compressed air dryer

# PNEUDRI



## Installation, Operating & Maintenance Instructions

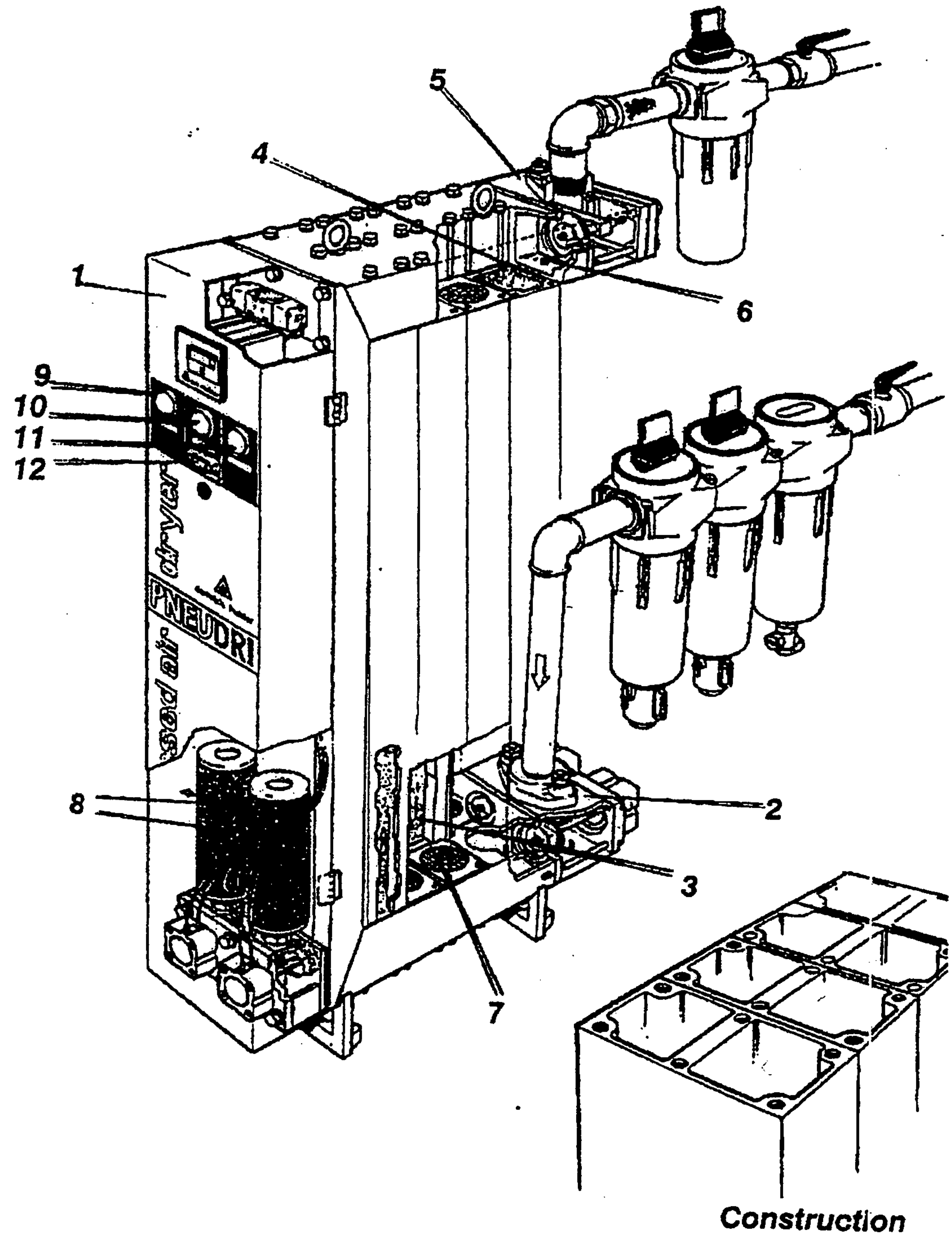



FIGURE 1 – TYPICAL HEATLESS DRYER CUTAWAY

# 2. TECHNICAL SPECIFICATIONS

## A) GENERAL

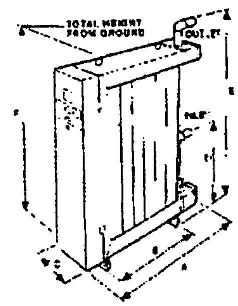
| PNEUDRI type: | Heatless | Heat Regenerative |
|---|---|---|
| Model: | DX | DH |
| Operating Flow Range: | 99 scfm – 1237 scfm<br>167 $Nm^3/h$ – 2102 $Nm^3/h$ | 68 scfm – 1100 scfm<br>116 $Nm^3/h$ – 1869 $Nm^3/h$ |
| Pressure Dewpoint: Nominal<br>Optional | −40°C(−40°F)<br>−70°C(−100°F) | |
| Air Quality:<br>(dirt/water/oil): | ISO 8573.1 Class 1.2.1<br>Class 1.1.1 optional | |
| Maximum Operating Pressure: | 10.5 barg (152 psig) | |
| Minimum Operating Pressure: | 4 barg (58 psig) | |
| Maximum Inlet Temperature: | 50°C (122°F) | |
| Minimum Inlet Temperature: | 5°C (41°F) | |
| Regeneration: | Pressure Swing Adsorption (PSA) [Air Purge Principle] | Thermal Swing Adsorption (TSA) [Heat & Air Purge Principle] |
| Nominal pressure drop across desiccant bed: | 140 mbar (2 psi) | |
| Standard Electrical Supply: | 240V/1ph/50Hz<br>(other voltages available) | 415V/3ph+ neutral / 50Hz |
| Controls: | Electric Cam Timer<br>(pneumatic option available) | Electric Cam Timer |
| Noise Level (Average): | 75db (A) | |
| Desiccant: | DRYFIL® (Zeolite Molecular Sieve) | |
| Inlet/Outlet Connections: | 2" BSPP flange up to and including 5 column units<br>2½" BSPP flange, 6 column units and above | |
| Material: | High tensile extruded aluminium coated with Alochrome anti–corrosion protection and paint finished with an abrasion resistant dry powder epoxy coating. | |
| Construction: | PNEUDRI is constructed from extruded aluminium sections connected together by high tensile bolts.ie. desiccant filled columns are contained between an upper and lower manifold. The configuration varies between the heatless and heat regenerative models as shown in figures 1 & 2. | |
| Pre filtration: | Grade AO/AA OIL–X filters | |
| After filtration: | Grade AR OIL–X filters | |

# 2. TECHNICAL SPECIFICATIONS

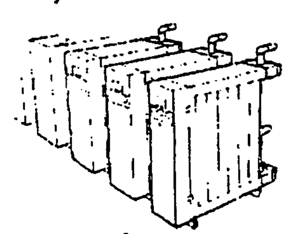
## B) FLOW RATES & DIMENSIONS

| Model | Max Inlet Temp °C | Nominal Flow Rates 4 bar g scfm | 4 bar g Nm³/h | 5 bar g scfm | 5 bar g Nm³/h | 6 bar g scfm | 6 bar g Nm³/h | 7 bar g scfm | 7 bar g Nm³/h | 8 bar g scfm | 8 bar g Nm³/h | 9 bar g scfm | 9 bar g Nm³/h | 10 bar g scfm | 10 bar g Nm³/h |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Heatless** | | | | | | | | | | | | | | | |
| DX102 | Up to 35 | 112 | 190 | 135 | 229 | 157 | 267 | 180 | 306 | 202 | 343 | 225 | 383 | 247 | 420 |
| | Up to 45 | 99 | 167 | 119 | 202 | 138 | 235 | 158 | 269 | 178 | 302 | 198 | 336 | 217 | 369 |
| DX103 | Up to 35 | 168 | 285 | 202 | 343 | 236 | 401 | 270 | 459 | 303 | 515 | 337 | 573 | 371 | 630 |
| | Up to 45 | 148 | 251 | 178 | 302 | 208 | 353 | 238 | 404 | 267 | 453 | 297 | 504 | 326 | 555 |
| DX104 | Up to 35 | 225 | 382 | 270 | 459 | 315 | 535 | 360 | 612 | 405 | 688 | 450 | 765 | 495 | 841 |
| | Up to 45 | 198 | 336 | 238 | 404 | 277 | 471 | 317 | 538 | 356 | 606 | 396 | 673 | 435 | 470 |
| DX105 | Up to 35 | 281 | 477 | 337 | 573 | 393 | 668 | 450 | 765 | 506 | 860 | 562 | 959 | 618 | 1050 |
| | Up to 45 | 247 | 420 | 297 | 504 | 346 | 588 | 396 | 673 | 445 | 757 | 495 | 840 | 544 | 924 |
| DX106 | Up to 35 | 337 | 573 | 405 | 688 | 472 | 802 | 540 | 917 | 607 | 1031 | 675 | 1147 | 742 | 1329 |
| | Up to 45 | 297 | 504 | 356 | 606 | 415 | 706 | 475 | 807 | 534 | 908 | 594 | 1009 | 688 | 1169 |
| DX107 | Up to 35 | 393 | 668 | 472 | 802 | 551 | 936 | 630 | 1070 | 708 | 1203 | 787 | 1337 | 866 | 1471 |
| | Up to 45 | 346 | 588 | 415 | 706 | 485 | 824 | 554 | 942 | 623 | 1059 | 693 | 1177 | 762 | 1295 |
| DX108 | Up to 35 | 450 | 765 | 540 | 917 | 630 | 1070 | 720 | 1223 | 810 | 1376 | 900 | 1529 | 990 | 1682 |
| | Up to 45 | 396 | 673 | 475 | 807 | 554 | 942 | 634 | 1076 | 713 | 1211 | 792 | 1346 | 871 | 1480 |
| DX110 | Up to 35 | 562 | 955 | 675 | 1147 | 787 | 1337 | 900 | 1529 | 1012 | 1719 | 1125 | 1911 | 1237 | 2102 |
| | Up to 45 | 495 | 840 | 594 | 1009 | 693 | 1177 | 792 | 1346 | 891 | 1513 | 990 | 1682 | 1089 | 1849 |
| **Heat Regenerative** | | | | | | | | | | | | | | | |
| DH102 | Up to 35 | 100 | 170 | 120 | 204 | 140 | 238 | 160 | 272 | 180 | 306 | 200 | 340 | 220 | 374 |
| | Up to 45 | 68 | 116 | 82 | 139 | 95 | 162 | 109 | 185 | 122 | 208 | 136 | 231 | 150 | 254 |
| DH104 | Up to 35 | 200 | 340 | 240 | 408 | 280 | 476 | 320 | 544 | 360 | 612 | 400 | 680 | 440 | 748 |
| | Up to 45 | 136 | 231 | 163 | 277 | 190 | 323 | 218 | 370 | 245 | 416 | 272 | 462 | 298 | 508 |
| DH106 | Up to 35 | 300 | 510 | 360 | 612 | 420 | 714 | 480 | 816 | 540 | 917 | 600 | 1019 | 660 | 1121 |
| | Up to 45 | 204 | 347 | 245 | 416 | 286 | 485 | 326 | 555 | 367 | 624 | 408 | 693 | 449 | 763 |
| DH108 | Up to 35 | 400 | 680 | 480 | 816 | 560 | 951 | 640 | 1087 | 720 | 1223 | 800 | 1359 | 880 | 1495 |
| | Up to 45 | 272 | 462 | 326 | 555 | 381 | 647 | 435 | 739 | 490 | 832 | 544 | 924 | 598 | 1017 |
| DH110 | Up to 35 | 500 | 850 | 600 | 1019 | 700 | 1189 | 800 | 1359 | 900 | 1529 | 1000 | 1699 | 1100 | 1869 |
| | Up to 45 | 340 | 578 | 408 | 693 | 476 | 809 | 544 | 924 | 612 | 1040 | 680 | 1155 | 743 | 1271 |

| Model | Dimension in mm A | B | C | D | E | F | Pipe Con. | Wt Kg. | Recom. Inlet Filter | Recom. Outlet Filter | Filter Con. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Heatless** | | | | | | | | | | | |
| DX102 | 692 | 239 | 240 | 831 | 1884 | 1630 | 2" | 135 | AO-0195G/G AA-0195G/G | AR-0195G/G | 2" |
| DX103 | 798 | 345 | 240 | 831 | 1884 | 1630 | 2" | 180 | AO-0195G/G AA-0195G/G | AR-0195G/G | 2" |
| DX104 | 905 | 452 | 240 | 831 | 1884 | 1630 | 2" | 220 | AO-0195G/G AA-0195G/G | AR-0195G/G | 2" |
| DX105 | 1011 | 558 | 240 | 831 | 1884 | 1630 | 2" | 250 | AO-0195G/G AA-0195G/G | AR-0195G/G | 2" |
| DX106 | 1118 | 665 | 240 | 1002 | 2198 | 1630 | 2 1/2" | 295 | AO-0375G/G AA-0375G/G | AR-0375G/G | 2 1/2" |
| DX107 | 1224 | 771 | 240 | 1002 | 2198 | 1630 | 2 1/2" | 345 | AO-0375G/G AA-0375G/G | AR-0375G/G | 2 1/2" |
| DX108 | 1311 | 878 | 240 | 1002 | 2198 | 1630 | 2 1/2" | 400 | AO-0375G/G AA-0375G/G | AR-0375G/G | 2 1/2" |
| DX110 | 1544 | 1091 | 240 | 1002 | 2198 | 1630 | 2 1/2" | 520 | AO-0375G/G AA-0375G/G | AR-0375G/G | 2 1/2" |
| **Heat Regenerative** | | | | | | | | | | | |
| DH102 | 717 | 264 | 321 | 831 | 1884 | 1630 | 2" | 150 | AO-0195G/G AA-0195G/G | AR-0195G/G | 2" |
| DH104 | 947 | 494 | 321 | 831 | 1884 | 1630 | 2" | 245 | AO-0195G/G AA-0195G/G | AR-0195G/G | 2" |
| DH106 | 1177 | 724 | 321 | 1002 | 2198 | 1630 | 2 1/2" | 325 | AO-0375G/G AA-0375G/G | AR-0375G/G | 2 1/2" |
| DH108 | 1407 | 954 | 321 | 1002 | 2198 | 1630 | 2 1/2" | 440 | AO-0375G/G AA-0375G/G | AR-0375G/G | 2 1/2" |
| DH110 | 1637 | 1184 | 321 | 1002 | 2198 | 1630 | 2 1/2" | 565 | AO-0375G/G AA-0375G/G | AR-0375G/G | 2 1/2" |



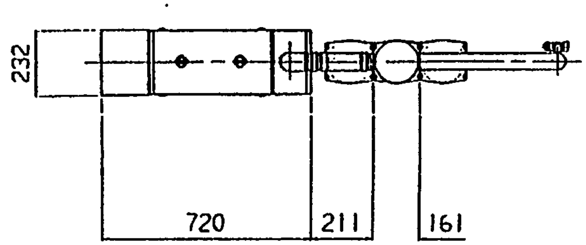

**Maxi Multiple banks**
**PNEUDRI**'s unique modular construction allows for higher flow rates to be catered for simply by using additional banks installed side by side.

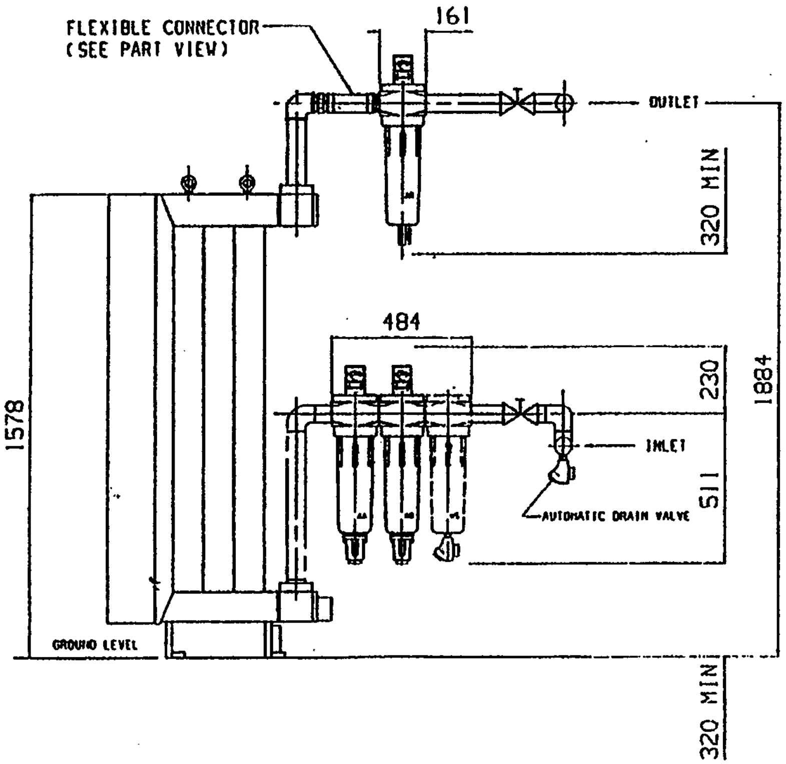


**EXAMPLE:** Three DX108 models will flow 1890 scfm at 6 bar g.

On Multibank installations ensure the minimum distance between centres is 500mm.

BASED ON B.S.308 — DO NOT SCALE IF IN DOUBT ASK — DIMENSIONS IN MILLIMETRES



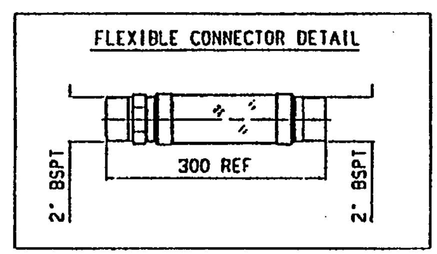

NOTE
****
AO-0220G. AA-0220G & AR-0220G FILTERS ARE REQUIRED FOR ALL INSTALLATIONS
IN EXTREME CONDITIONS THE ADDITION OF A WATER SEPARATOR TYPE WS400 IS
RECOMMENDED.

FLEXIBLE CONNECTOR WHICH HOUSES FLOW CONTROL DEVICE IS SUPPLIED WITH EACH DRYER BANK.
ALL OTHER PIPEWORK FITTINGS & VALVES TO BE SUPPLIED BY CUSTOMER.

INDIVIDUAL DRYER PIPEWORK - 2" NB.

IF PURGE (EXHAUST) AIR IS TO BE PIPED AWAY FROM DRYER REFER TO DRAWING 101-2464.

TECHNICAL SPECIFICATION
**********************
NOMINAL INLET FLOW RATE @ 35°C & 6bar g...........236 scfm.




| REV | ECO No. | DATE | NAME |
|---|---|---|---|
| 2 | 8999 | 22Nov94 | DMC |
| 1 | 6851 | 18May93 | JH |
| 0 | 6175 | 20Oct92 | DEB |

DOMNICK HUNTER LIMITED

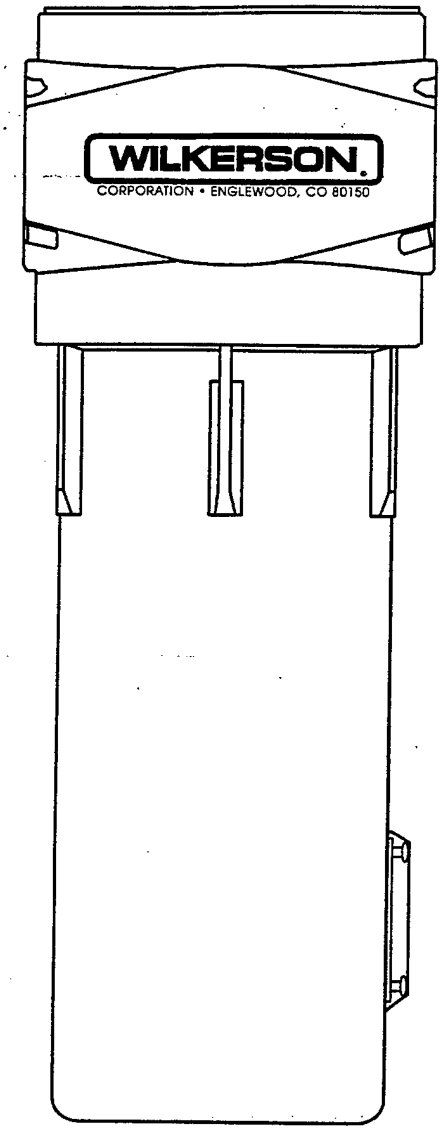
DX103

DRG. No 101 2464 SHEET 1 of 1

**WILKERSON®**
**CORPORATION**

83-230-000
# INSTRUCTION SHEET
## Liquid Separator

EXCEPT as otherwise specified by the manufacturer, this product is specifically designed for compressed air service, and use with any other fluid (liquid or gas) is a misapplication. For example, use with or injection of certain hazardous liquids or gases in the system (such as alcohol or liquid petroleum gas) could be harmful to the unit or result in a combustible condition or hazardous external leakage. Manufacturer's warranties are void in the event of misapplication, and manufacturer assumes no responsibility for any resulting loss. Before using with fluids other than air, or for non-industrial applications, consult manufacturer for written approval.



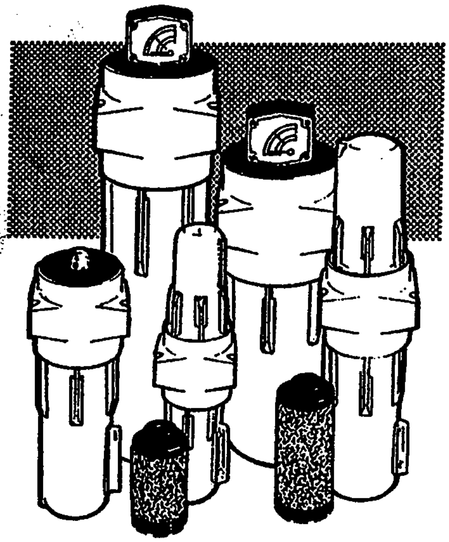

**MAINTENANCE**

1. EACH TIME THE BOWL IS CLEANED:
   a. Depressurize unit.
   b. Inspect seals and replace crazed, cracked, damaged or deteriorated seals with original manufacturer's approved seals only.
2. Before placing unit in service, be sure that the bowl is reinstalled and securely locked in position.

**REPAIR KITS:**

Sight Gauge .......... GRP-96-070
Bowl O-ring Kit .......... GRP-96-071

**SULLAIR®**



## INSTALLATION MANUAL

**HANDBUCH ● MANUEL ● HANDLEIDING ● MANUAL ● MANUALE DI INSTALLAZIONE ● BETJENINGSVEJLEDNING ● MANUAL DE INSTALAÇÃO ●** ΕΓΧΕΙΡΙΔΙΟ ΕΓΚΑΤΑΣΤΑΣΗΣ ● **INSTALLATIONSHANDBOK ● OHJEKIRJA ●** 据付けマニュアル ● كتيب التركيب ●

# SULLAIR

## MPF, MPH, MPC, MPHC

## FILTERS FOR COMPRESSED AIR & GASES

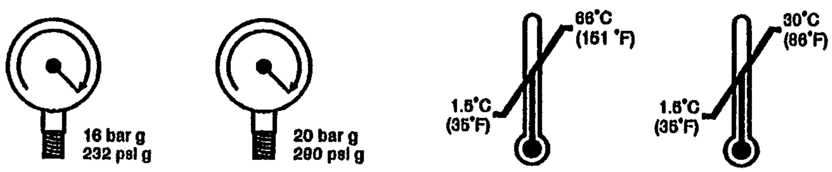
**FILTER FÜR DRUCKLUFT UND GASE ● FILTRES D'AIR COMPRIME ET DE GAZ ● FILTERS VOOR PERSLUCHT EN GECOMPRIMEERDE GASSEN ● FILTROS PARA AIRE COMPRIMIDO Y GASES ● FILTRI PER ARIA COMPRESSA E GAS ● FILTRE TIL TRYKLUFT OG-GAS ● FILTROS PARA AR E GASES COMPRIMIDOS ●** ΦΙΛΤΡΑ ΓΙΑ ΣΥΜΠΙΕΣΜΕΝΟ ΑΕΡΑ & ΑΕΡΙΑ **● FILTER FÖR TRYCKLUFT OCH GASER ● SUODATTIMIA PAINEILMAA JA KAASUJA VARTEN ●** 圧搾空気/圧縮ガス用フィルター ● المرشحات للهواء المضغوط والغازات ●

CE

# TECHNICAL SPECIFICATION

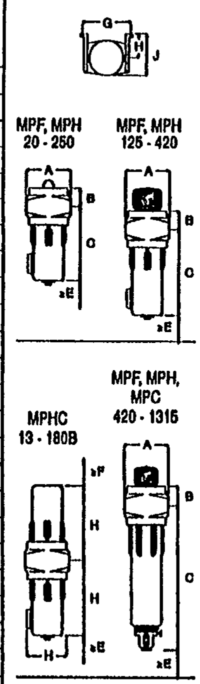
TECHNISCHE ANGABEN ● CAHIER DES CHARGES ● TECHNISCHE SPECIFICATIE ● ESPECIFICACIONES TECNICAS ● SPECIFICA TECNICA ● TEKNISK SPECIFIKATION ● ESPECIFICAÇÕES TÉCNICAS ● ΤΕΧΝΙΚΕΣ ΠΡΟΔΙΑΓΡΑΦΕΣ ● TEKNISK SPECIFIKATION ● TEKNISET TIEDOT ● 技術仕様 ● المواصفات الفنية ●

**Maximum Working Pressure**
Maximaler Betriebsdruck ● Pression maxi d'utilisation ● Maximale werkdruk ● Presion Maxima de Trabajo ● Pressione Massima di Lavoro ● Maximum arbejdstryck ● Pressão Operacional Máxima ● ΜΕΓΙΣΤΗ ΠΙΕΣΗ ΛΕΙΤΟΥΡΓΙΑΣ ● Maximalt arbetstryck ● Maksimikäyttöpaine ● 最大使用圧力 ● أقصى ضغط تشغيل ●



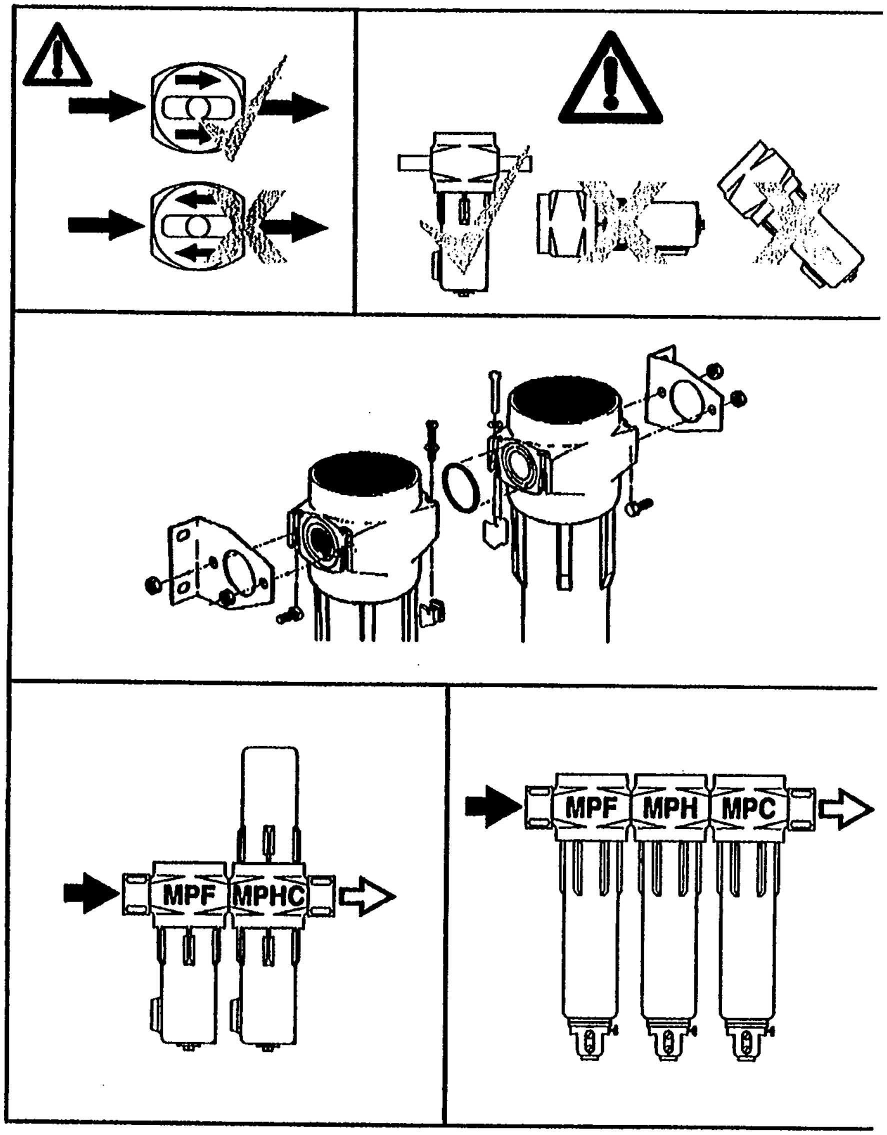

| MPF, MPH, MPHC | MPC | MPF, MPH, MPHC | MPC |
|---|---|---|---|

| Model | NPT/BSP | A | B | C | D | E | F | G | H | J | kg | lbs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dimensions mm/ins | | | | | | | | | | |
| 20 | ¼ | 76 | 34.5 | 133 | 133 | 70 | 70 | 115 | 45 | 78 | 0.5 | 2.2 |
| | | 3.0 | 1.4 | 5.2 | 5.2 | 2.8 | 2.8 | 4.5 | 1.8 | 3.1 | 1.0 | 2.2 |
| 35 | ⅜ | 89 | 42 | 158 | 158 | 95 | 95 | 128 | 52 | 93 | 1.0 | 2.2 |
| | | 3.5 | 1.65 | 6.2 | 6.2 | 3.7 | 3.7 | 5.0 | 2.1 | 3.7 | 1.2 | 2.7* |
| 65 | ½ | 89 | 42 | 194 | 158 | 130 | 95 | 128 | 52 | 93 | 1.1 | 2.4* |
| | | 3.5 | 1.65 | 7.6 | 6.2 | 5.1 | 3.7 | 5.0 | 2.1 | 3.7 | 1.4* | 3.1* |
| 125 | ¾ | 120 | 58 | 251 | 251 | 172 | 125 | 163 | 68 | 125 | 2.4 | 5.3 |
| | | 4.7 | 2.3 | 9.9 | 9.9 | 6.8 | 4.9 | 6.4 | 2.7 | 4.9 | 3.2* | 7.1 |
| 170 | 1 | 120 | 58 | 351 | 251 | 272 | 125 | 163 | 68 | 125 | 2.9 | 6.4 |
| | | 4.7 | 2.3 | 13.8 | 9.9 | 10.7 | 4.9 | 6.4 | 2.7 | 4.9 | 3.7* | 8.2* |
| 250 | 1¼ | 120 | 58 | 351 | 351 | 272 | 225 | 163 | 68 | 125 | 2.9 | 6.4 |
| | | 4.7 | 2.3 | 13.8 | 13.8 | 10.7 | 8.9 | 6.4 | 2.7 | 4.9 | 3.8* | 8.4* |
| 300 | 1½ | 120 | 58 | 351 | 351 | 272 | 225 | 163 | 68 | 125 | 2.9 | 6.4 |
| | | 4.7 | 2.3 | 13.8 | 13.8 | 10.7 | 8.9 | 6.4 | 2.7 | 4.9 | 3.8* | 8.4* |
| 420 | 1½ | 160 | 66.5 | 511 | - | 320 | - | 213 | 92 | 169 | 9.1 | |
| | | 6.3 | 2.6 | 20.1 | - | 12.6 | - | 8.4 | 3.6 | 6.6 | 20 | |
| 470 | 2 | 160 | 66.5 | 511 | - | 320 | - | 213 | 92 | 169 | 9.1 | |
| | | 6.3 | 2.6 | 20.1 | - | 12.6 | - | 8.4 | 3.6 | 6.6 | 20 | |
| 850 | 2½ | 202 | 79 | 602 | - | 400 | - | 280 | 135 | 235 | 12.1 | |
| | | 7.9 | 3.1 | 23.7 | - | 15.7 | - | 11.0 | 5.3 | 9.3 | 27 | |
| 910 | 3 | 202 | 79 | 602 | - | 400 | - | 280 | 135 | 235 | 11.9 | |
| | | 7.9 | 3.1 | 23.7 | - | 15.7 | - | 11.0 | 5.3 | 9.3 | 26 | |
| 1315 | 3 | 202 | 80.5 | 844 | - | 625 | - | 280 | 135 | 235 | 31.5 | |
| | | 7.9 | 3.2 | 33.2 | - | 24.6 | - | 11.0 | 5.3 | 9.3 | 69 | |




# INSTALLATION

INSTALLATION ● INSTALLATION ● PLAATSING ● INSTALACION ● INSTALLAZIONE ● MONTERING ● INSTALAÇÃO ● ΕΓΚΑΤΑΣΤΑΣΗ ● INSTALLATION ● ASENNUS ● 取付け ● التركيب ●



# HYGRODYNAMICS

## DIGITAL
## DEW POINT MONITOR

MODEL 8097
8097-230VAC

**TABLE OF CONTENTS**



**DIAGRAMS**




NEWPORT SCIENTIFIC, INC.
8246-E SANDY COURT
JESSUP, MARYLAND 20794-9632
PHONE (301) 498-6700 FAX (301) 490-2313


February 1994

DEW POINT MONITOR
MODEL 8097

## SPECIFICATIONS

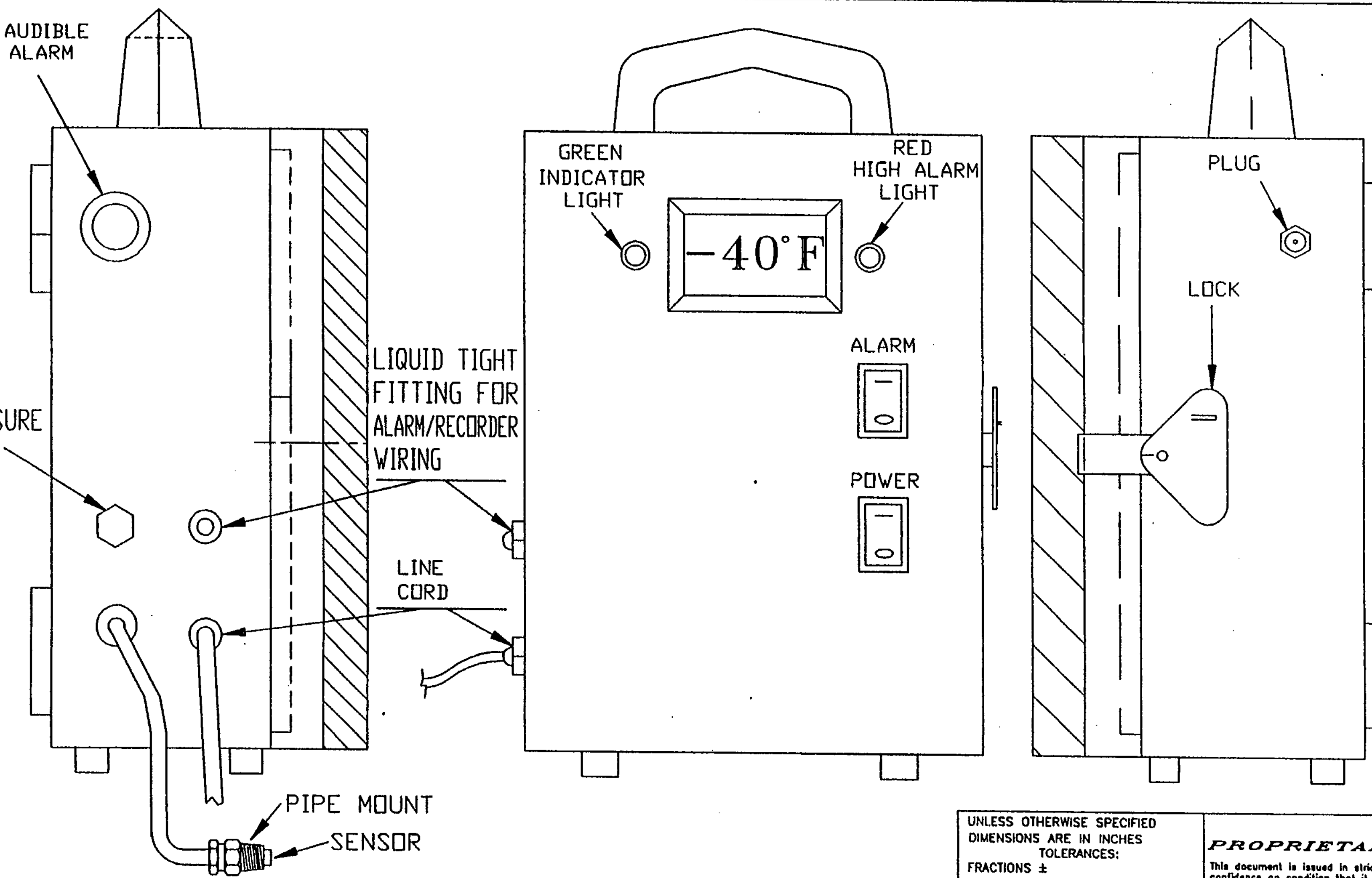
| | |
|---|---|
| **Dew Point Range:** | -40°F to +15°F (-40°C to -9°C) |
| **Recorder Ouput:** | 4-20mA Scaled as -40°F to +70°F<br>$mA = \frac{DP + 67.5}{6.875}$ or $V = \frac{DP + 40}{22}$<br>-40 = 4mA or 0V 70 = 20mA or 5V |
| **Alarm Indication:** | Red Light and Audible Alarm With Silencer Switch. |
| **Alarm Output:** | 5AMP @ 115VAC Rated Contact. Normally Open and Normally Closed Dry Contacts. |
| **Alarm Set Point:** | -10°F (-23°C) (Adjustable, see Maintenance) |
| **Accuracy:** | ±2°F Dew Point |
| **Sensor Part No.:** | 1205DM |
| **Dimensions:** | 10½" x 8½" x 6 |
| **Net Weight:** | 6 lbs. |
| **Enclosure:** | Lexan NEMA-12 Electrical Box, CSA Approved. Wall Mountable or Portable With Removable Front Cover. |
| **Power Requirements:** | 115VAC ±10%, 50-60 Hz, 0.1 Amps **(230V available)** |
| **Pressure Range:** | 0 - 300 psig |

## PRINCIPLE OF OPERATION

The 8097 Dew Point Monitor is designed to monitor the dew point of compressed air in the range of -40°F to +15°F. The unit is equipped with a remote sensor in a pipe fitted housing. The Dew Point Monitor is connected to the sensor by a 10 ft electrical cable.

The HYGROSENSOR consists of a bifilar winding of palladium wire wound on an insulating core. The surface is coated with a thin film mixture of LiBr and PVA (polyvinyl alcohol). The sensor varies its electrical resistance inversely proportional to the moisture in the surrounding atmosphere.

The 8097's internal circuit excites the sensor with a regulated AC voltage and measures the dewpoint in terms of electrical current. The signal is used to drive the digital meter and a comparator circuit which provides relay contact closure.




UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ±
DECIMALS ±
ANGLES ±
REMOVE ALL BURRS AND SHARP EDGES
DO NOT SCALE THIS DRAWING

*PROPRIETARY*



HYGRODYNAMICS® NEWPORT SCIENTIFIC INC.

| BY | NAME | DATE |
|---|---|---|
| PREPARED | | |
| CHECKED | | |
| ENGR/DSGN | FSD | 8/94 |
| APPROVED | | |
| MATERIAL | | |

FINISH:

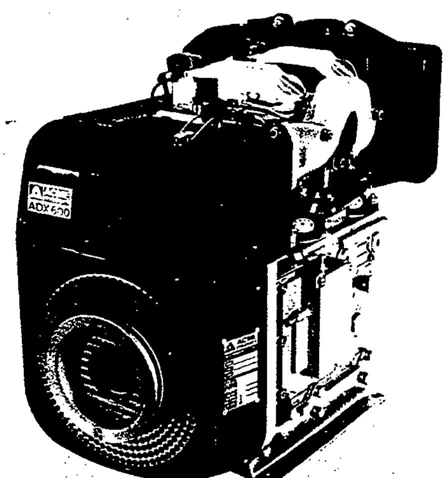
TITLE GENERAL ARRANGEMENT DEW POINT MONITOR

| CODE IDENT. NO. | SIZE | PART NO. 8097 |
|---|---|---|
| 59505 | A | DRAWING NO. 8097 |
| SCALE NONE | WEIGHT | SHEET OF |

USO - MANUTENZIONE - RICAMBI
*USE - MAINTENANCE - SPARE PARTS*
EMPLOI - ENTRETIEN - PIECES DETACHEES
*BEDIENUNG - WARTUNG - ERSATZTEILE*
EMPLEO - MANTENIMIENTO - REPUESTOS

# ADX 600 - 740

ACME motori



## CARATTERISTICHE - CHARACTERISTICS - CARACTERISTIQUES - MERKMALE - CARACTERISTICAS

Bicilindrico - Ciclo Diesel 4 tempi - Iniezione diretta - Raffredamento ad aria forzata - Lubrificazione forzata con pompa ad ingranaggi - Avviamento elettrico - Regolatore di giri automatico centrifugo - Carter in alluminio pressofuso - Cilindro in ghisa perlitica - Filtro a secco (a bagno olio su richiesta).

*Twin cylinder - 4-stroke Diesel cycle - Direct injection - Forced air cooling - Forced lubrification by gear pump - Electric starting - Automatic centrifugal speed governor - Die cast aluminium crankcase - Pearlitic cast -iron cylinder - Dry air cleaner (oil bath type as optional).*

Bicylindrique - Cycle Diesel 4 temps - Injection directe - Refroidissement par air forcé - Lubrification forcée par pompe à engrenages - Demarrage electric -. Régulateur de tours automatique centrifuge - Carter en aluminium coulé sous pression - Cylindre en fonte perlitique - Filtre à sec (à bain d' huile sur demande).

*Zweizylinder - Arbeitsweise: Diesel 4-Takt - Direkteinspritzung - Kühlart: mit Zwangsluft - Zwangsschmierung mit Zahradpumpe - Elektrostart - Automatischer Fliehkraftregler - Drehzahlregler - Kurbelgenhäuse aus Aluminium-Druckguss - Zylinder aus Perlitguss - Oelbadluftfilter.*

Bicilindrico - Ciclo Diesel de 4 tiempos - Inyección directa - Enfriamiento por aire forzado - Lubricación forzada con bomba de engranajes - Arranque elétrico - Regulador de revoluciones automático centrifugo - Bloque presofundido en aluminio - Cilindro en fundiciòn perlitica - Filtro de aire en seco (en baño de aceite con prefiltro a ciclon a petición).

| MODELLO<br>TYPE<br>TYPE<br>TYP<br>TIPO | | ADX 600 | ADX 740 |
|---|---|---|---|
| Cilindri<br>Cylinders<br>Cylindres<br>Zylinder<br>Cilindros | n | 2 | 2 |
| Corsa<br>Stroke<br>Course<br>Hub<br>Carrera | mm | 70 | 70 |
| Alesaggio<br>Bore<br>Alésage<br>Bohrung<br>Diamètro | mm | 74 | 82 |
| Cilindrata<br>Displacement<br>Cylindrée<br>Hubraum<br>Cilindrada | $cm^3$ | 602 | 740 |
| Giri/min<br>R.P.M.<br>Tours/min<br>U./min<br>R.P.M. | | 3000<br>3600 | 3000<br>3600 |
| Capacità serbatoio<br>Fuel tank capacity<br>Contenance du réservoir<br>Tankhinalt<br>Capacidad dèposito | l | 4.5 | 4.5 |
| Capacità carter olio<br>Oil sump capacity<br>Contenance carter huile<br>Schmieröflullung<br>Capacidad carter aceite | l | 2.1 | 2.1 |
| Peso a secco<br>Dry weight<br>Poids à vide<br>Trockengewicht<br>Peso en seco | kg | 62 | 64 |

### NORME DI SICUREZZA - SAFETY RULES - NORMES DE SICURITE - SICHERHEITSMASSNAHMEN - NORMAS DE SEGURIDAD

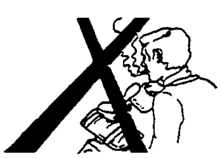
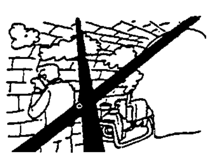
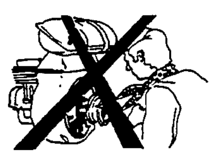
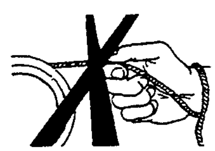
**NOTE:** Questo simbolo attira l'attenzione su importanti norme di sicurezza che, se non rispettate, possono causare danni alla sicurezza personale vostra o altrui.

***NOTE:*** *This symbol points out important safety instructions which, if not followed, could endanger the personal safety of yourself or other people.*

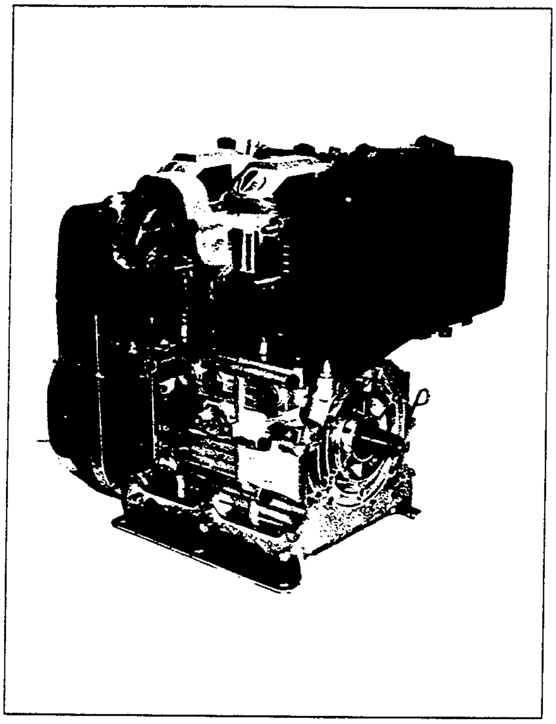
**REMARQUE:** Ce symbole attire l'attention sur des normes de securité importantes qui, si non respectées, peuvent nuire a votre securité personelle et a celle d'autrui.

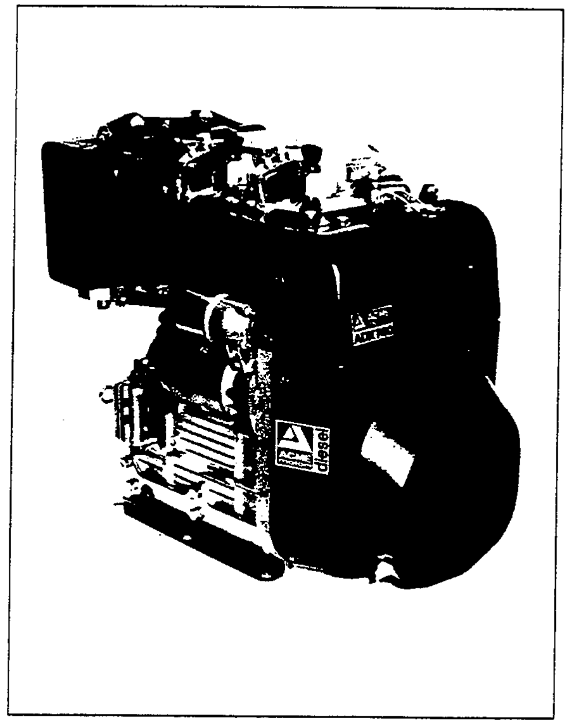
***BEMERKUNG:*** *Dieses Zeichen weist auf wichtige Sicherheitsanweisungen hin, deren Missachtung ihre persoenliche Sicherheit oder die anderer Personen gefaehrdet.*

**NOTAS**: Este simbolo llama l'atencion sobre importantes normas de seguridad las cuales, si no son respectadas, pueden causar daños a la seguridad personal o de otros.

# 11 VARIATIONS FOR ENGINES TYPE ADX 600 - 740





## 11.1 ENGINE SPECIFICATIONS

| ENGINE MODEL | RPM | NUMBER OF CYLINDERS | BORE | | STROKE | | DISPLACEMENT | | COMPRESSION RATIO |
|---|---|---|---|---|---|---|---|---|---|
| | | | mm | in | mm | in | $cm^3$ | cu.in | |
| **ADX 600** | 3000/3600 | 2 | 74 | 2.91 | 70 | 2.76 | 602 | 36.7 | 1 : 19 |
| **ADX 740** | 3000/3600 | 2 | 82 | 3.23 | 70 | 2.76 | 740 | 45.1 | 1 : 19 |

# SAFETY INSTRUCTIONS (enclosed for use with maintenance manual)

• ACME engines are built to provide safe and long-lasting performance, but in order to obtain these results it is essential that the maintenance requirements described in the manual are observed along with the following safety recommendations.

• The engine has been built to the specifications of a machine manufacturer, and it is his responsibility to ensure that all necessary action is taken to meet the essential and legally prescribed health and safety requirements. Any use of the machine other than that described cannot be considered as complying with its intended purpose as specified by ACME, which therefore declines all responsibility for accidents caused by such operations.

• The following instructions are intended for the user of the machine in order to reduce or eliminate risks, especially those concerning the operation and standard maintenance of the engine.

• The user should read these instructions carefully and get to know the operations described. By not doing so he may place at risk his own health and safety and that of anyone else in the vicinity of the machine.

• The engine may be used or mounted on a machine only by personnel suitably trained in its operation and aware of the dangers involved. This is particularly true for standard and, above all, special maintenance work. For special maintenance contact personnel trained specifically by ACME. This work should be carried out in accordance with existing literature.

• ACME declines all responsibility for accidents or for failure to comply with the requirements of law if changes are made to the engine's functional parameters or to the fuel flow rate adjustments and speed of rotation, if seals are removed, or if parts not described in the operating and maintenance manual are removed and reassembled by unauthorized personnel.

• In addition to all other machine specifications, ensure that the engine is in a near horizontal position when starting. If starting manually, ensure that the necessary operations can be performed without any risk of striking against walls or dangerous objects. Rope starting (except for recoil rope starting) is not permitted even in emergencies on diesel engines.

• Check that the machine is stable so that there is no risk of it overturning.

• Get to know the engine speed adjustment and machine stop operations.

• Do not start the machine in closed or poorly ventilated environments. The internal combustion process generates carbon monoxide, an odourless and highly toxic gas, so spending too long a time in an environment where the engine discharges its exhaust products freely can lead to loss of consciousness and even death.

• The engine may not be used in environments containing flammable materials, explosive atmospheres or easily combustible powders, unless adequate and specific precautions have been taken and are clearly stated and certified for the machine.

• To prevent the risk of fire, keep the machine at a distance of at least one metre from buildings or other machines.

• Children and animals must be kept at a sufficient distance from the machine to prevent any danger resulting from its operation.

• Fuel is flammable, so the tank must be filled only when the engine is turned off. Dry carefully any fuel that may have spilled, remove the fuel container and any cloths soaked in fuel or oil, check that any sound-absorbing panels made of porous material are not soaked with fuel or oil, and make sure that the ground on which the machine is located has not absorbed fuel or oil.

• To start the engine follow the specific instructions provided in the engine and/or machine operating manual. Do not use auxiliary starting devices not originally installed on the machine (e.g. Startpilot systems which utilise ether etc. on diesel engines).

• Before starting, remove any tools that have been used for carrying out maintenance work to the engine and/or the machine and check that any guards removed have been replaced. In cold climates it is possible to mix kerosene with the diesel fuel to make the engine easier to start. The liquids must be mixed in the tank by pouring in first the kerosene and then the diesel fuel. Consult ACME technical office for mixture proportions.

• During operation the surface of the engine reaches temperatures that may be dangerous. Avoid in particular all contact with the exhaust system.

• Before carrying out any work on the engine, turn it off and allow it to cool down. Do not perform any operation while the engine is running.

• While cleaning the oil bath air filter, check that the oil is disposed of in such a way as not to harm the environment. Any filtering sponges in the oil bath air filter should not be soaked with oil. The cyclone pre-filter cup must not be filled with oil.

• Since the oil must be emptied out while the engine is still hot (approx. 80°C), particular care should be taken in order to avoid burns. In any case make sure that oil does not come into contact with your skin because of the health hazards involved.

• Check that the discharged oil, the oil filter and the oil contained in the oil filter are disposed of in such a way as not to harm the environment.

• Close the fuel tank filler cap carefully after each filling operation. Do not fill the tank right up to the top, but leave sufficient space to allow for any expansion of the fuel.

• Fuel vapours are highly toxic, so fill up only in the open air or in well ventilated environments.

• Do not smoke or use naked flames while filling.

• Take care when removing the oil filter as it may be hot.

• During operations which involve access to moving parts of the engine and/or removal of the rotary guards, disconnect and insulate the positive cable of the battery so as to prevent accidental short circuits and activation of the starter motor.

• Check the belt tension only when the engine is turned off.

• In order to move the engine use exclusively the eyebolts fitted for this purpose by ACME. These lifting points are however not suitable for the entire machine, so in this case use the eyebolts fitted by the manufacturer.

# APPENDIX C

## ALPHEUS CLEANING TECHNOLOGIES OPERATING and SAFETY TRAINING COURSE OUTLINE

- COURSE OUTLINE
- MAINTENANCE
- TROUBLE SHOOTING
- OPERATOR TEST
- PERSONNEL CERTIFICATIONS

ALPHEUS CLEANING TECHNOLOGIES

# SDI/PLT

# Service & Sales Training Outline

1. **Identify equipment and purpose of use:**
   SDI PLT

2. **Discuss hazards:**
   Asphyxiation
   Burn Hazard
   Pellets
   Static
   Pinch Points
   Cutter Hazard
   Stored Pressure (air)
   Lifting Blocks
   Transferring Pellets

3. **Attire:**
   Long Pants
   Long Sleeve Shirts
   Gloves
   Safety Shoes
   Eye Protection
   Ear Protection
   Any Additional Gear as Required for Individual Applications

4. **Air Supply:**
   Pressure
   SCFM
   Clean Lines
   Minimum/Maximum
   Separators
   Dryers

5. **Stingers & Nozzles:**
   Explain how they function
   Explain purpose of combinations and effects of mismatch
   Demonstrate installation & removal
   Review selection chart in manual
   Tools required

6. **Operation:**
   Air Connections
   Blow Down Lines
   Safety Whips
   Explain Control Panel
   Explain Machine Components
   Daily Checks i.e., Separator, Oiler, Valve Positions
   Connection of Blast Hose and Gun
   Grounding
   Loading of Ice
   Measuring Make Rates
   Methods of Disarming Trigger i.e., "E" Stop, Vent/Run
   Instrument Air
   Start Up and Shut Down Procedures
   Blasting Techniques

7. **Maintenance:**

| | |
|---|---|
| Daily | Types of Oils, Grease |
| Weekly | Cleanliness |
| Hourly | Extended Shutdown |

8. **Troubleshooting:**

| | |
|---|---|
| Causes/Remedies | Blast Gun |
| Breakdown Into Sections | Controls |
| Trough | Review Manual |
| Air System | Review Flow Schematic & Parts List |
| Blast Hose | Encourage Calls |

9. **Conclusion:**
   - Review and Encourage Questions
   - Encourage Experimentation of Other Uses
   - Pass Out Service Number
   - Service Report Signed
   - Give Test/Results

# PLT AIRLOCK
# MAINTENANCE & SETTINGS

## MAINTENANCE

1. ***Airlock Motor Oiler*** should be checked daily. It should **NEVER** be allowed to run dry. The appropriate oil is SAE 10 wt. air tool oil. Add oil to full level on reservoir.
2. ***Airlock Gear Reduction Box*** uses SAE 140 wt. gear oil and should be changed yearly or at 2500 hours, whichever occurs first. Oil level should be approx. 2"-3" from the bottom of the gearbox. Check monthly.
3. ***Airlock Bearing***, (P/N 11075-001), should be replaced every 2 thousand hours or every 2 years of service, whichever occurs first.

## SETTINGS

1. Transport air should be set to 70 PSI
2. Airlock motor regulator should be set to 40 PSI

## TROUBLESHOOTING THE PLT

| SYMPTOM | PROBABLE CAUSE | REMEDY |
|---|---|---|
| Miniblast unit will not start. | Air inlet valve at rear of unit not open. | Open inlet valve. |
| | "E" Stop in off position. | Reset "E" Stop button. |
| | Vent/run switch is in vent position. | Select the run position on the switch. |
| | Safety screen not positioned properly. | Reposition screen. |
| | Interlock switch not fully depressed | Adjust interlock |
| | Trigger lines either leaking or improperly connected. | Checking connections. |
| | Instrument air pressure is too low | Increase the instrument air pressure to the recommended range (75-90 PSI) |
| Auger motor will not rotate. | Air pressure is below 20 PSIG. | Increase motor pressure |
| | Instrument air pressure is lower than the pressure on the motor. | Raise instrument air pressure to 75-90 PSIG. |
| | Auger frozen. | Open flapper and thaw with blast air |
| | Auger bushing worn. | Replace bushing. |

## TROUBLESHOOTING THE PLT

| SYMPTOM | PROBABLE CAUSE | REMEDY |
|---|---|---|
| Hammer does not strike. | Low instrument air pressure. | Increase the instrument air pressure to 75-90 PSIG. |
| | Hammer is sticking inside housing | Disassemble the hammer, clean the insert, coat with a thin coat of automatic transmission fluid prior to re-assembly, remove any excess lubricant, clean all parts and re-assemble. |
| Miniblast works in empty hopper mode but not in run mode. | Low blast pressure | Blast pressure must not be below 20 PSI. |
| | Low instrument pressure | Instrument air pressure must be set at a minimum of 75 PSI. |
| | Leak or improper connections in the trigger lines | Check trigger lines. |
| When trigger is pulled, pellets blow out of auger flapper. | Hoses on gun reversed. | Reverse hoses at blast gun. |
| When trigger is released unit continues to blast even if "E" Stop is activated. | Purge delay is out of adjustment. | Adjust purge delay. |
| Pellet flow is interrupted after extended blasting. | Ice formation in suction port. | Press "E" Stop to disable auger. Open flapper and clear any accumulation in suction port. |

1. When blast trigger is released and gun continues to blast, what is the most probable cause?

    (A) Trigger line disconnected
    (B) Moisture in regulator
    (C) Blast hoses reversed
    (D) All of the above.

2. After blasting for an extended period, pellet flow becomes intermittent, what is the reason?

    (A) Ice formation in the blast hose
    (B) Hoses reversed
    (C) No pellets in the machine
    (D) None of the above.

3. What happens when the trigger is pulled, auger will not turn, but there is no indication of freezing?

    (A) Instrument air pressure is lower than line pressure
    (B) Bushing is worn
    (C) Supply air is 20 PSI
    (D) All of the above

4. Miniblast has 110 PSI supply air and instrument air is 80 PSI, but unit will not run because?

    (A) Interlock is fully depressed
    (B) Safety screen is out of position
    (C) All of the above
    (D) None of the above

5. Miniblast is ready to run, but when trigger is pulled unit will not run. Why?

    (A) Vent/Run switch is in run position
    (B) "E" Stop is off
    (C) Interlock is fully depressed
    (D) None of the above

6. When blasting, large amounts of oil escape from muffler because:

    (A) Too much moisture in air supply
    (B) Motor oil is overfilled
    (C) Oiler is out of adjustment
    (D) None of the above

7. If line supply is 95 PSI, but when trigger is pulled pressure drops to 50 PSI, causing poor cleaning, it is probably due to:

   (A) Too many other machines running in plant
   (B) Poor ice quality
   (C) Mismatched stinger and nozzle
   (D) Leak in hoses

8. Miniblast is ready for operation, but will not run when trigger is pulled because:

   (A) Trigger lines improperly connected
   (B) Supply valve not open
   (C) Too much air pressure
   (D) Moisture in air supply

9. When blasting there appears to be a mist of water coming out of the nozzle because:

   (A) Poor quality of pellets
   (B) Lid is open
   (C) Contaminated air supply
   (D) All of the above

10. What effect will contaminated air have on the unit?

   (A) No effect at all
   (B) Increased cleaning ability
   (C) No cleaning ability
   (D) Plugging and clogging of the machine

## ANSWER KEY - PLT

1. C
2. A
3. D
4. B
5. B
6. C
7. C
8. A
9. C
10. D

## ANSWER KEY - SDI

1. C
2. D
3. C
4. C
5. C
6. B
7. B
8. D
9. D
10. D

# CERTIFICATION

**FOR OPERATIONS, USAGE AND MAINTENANCE OF**

$CO_2$

**MiniBlast**tm

**MODEL PLT-HV**

**AWARDED TO**

# EDWARD DURLAK

**NAVAL FACILITIES ENGINEERING SERVICE CENTER**

*For satisfactory completion of a course of instruction conducted at Alpheus headquarters by a certified Alpheus Service Technician.*

*Completed this 17th day of October, 1997.*

ALPHEUS Cleaning Technologies

TRAINING SUPERVISOR

PRESIDENT

# CERTIFICATION

**FOR OPERATIONS, USAGE AND MAINTENANCE OF**

$CO_2$

**MiniBlast**tm

**MODEL PLT-HV**

**AWARDED TO**

## LOUIS BANNISTER

NAVY PUBLIC WORKS CENTER

*For satisfactory completion of a course of instruction conducted at Alpheus headquarters by a certified Alpheus Service Technician.*

*Completed this 17th day of October, 1997.*

ALPHEUS Cleaning Technologies

TRAINING SUPERVISOR

PRESIDENT

# CERTIFICATION

**FOR OPERATIONS, USAGE AND MAINTENANCE OF**

$CO_2$

**MiniBlast** tm

MODEL PLT-HV

**AWARDED TO**

## ROLANDO D. ROSAL

NAVY PUBLIC WORKS CENTER

*For satisfactory completion of a course of instruction conducted at Alpheus headquarters by a certified Alpheus Service Technician.*

*Completed this 17th day of October, 1997.*

ALPHEUS Cleaning Technologies

Kenneth A. Mickle Jr.

TRAINING SUPERVISOR

PRESIDENT

# CERTIFICATION

**FOR OPERATIONS, USAGE AND MAINTENANCE OF**

$CO_2$

**MiniBlast**™

**MODEL PLT-HV**

**AWARDED TO**

## ALFONSO A. JO

NAVY PUBLIC WORKS CENTER

*For satisfactory completion of a course of instruction conducted at Alpheus headquarters by a certified Alpheus Service Technician.*

*Completed this 17th day of October, 1997.*

ALPHEUS Cleaning Technologies

Kenneth A. Mikk Jr.

**TRAINING SUPERVISOR**

**PRESIDENT**

# CERTIFICATION

**FOR OPERATIONS, USAGE AND MAINTENANCE OF**

$CO_2$

**MiniBlast**tm

**MODEL PLT-HV**

**AWARDED TO**

## RICHARD JUAREZ

**NAVY PUBLIC WORKS CENTER**

*For satisfactory completion of a course of instruction conducted at Alpheus headquarters by a certified Alpheus Service Technician.*

*Completed this 17th day of October, 1997.*

ALPHEUS Cleaning Technologies

TRAINING SUPERVISOR

PRESIDENT

# APPENDIX D

## $CO_2$ PELLET CLEANING STANDARD OPERATING PROCEDURES

# SYSTEM OVERVIEW

**Procedure:** Cleaning metal enclosed switch gear rated at 15kv a.c. while energized.

**Process:** Carbon Dioxide in the solid state, and extruded .125 inch rice pellets are delivered through insulated live line sticks. The blasting medium ( dry ice pellets) is propelled with dry high pressure air unto the energized buss insulating, supports, phase barriers, fuses, and cable terminators. Cleaning is accomplished with a light sweeping motion across the front and sides of each component.

**Equipment Operation**

- **Compressor:** Provides high pressure air for use as the propellant of the blasting medium, the drive for the AIR LOCK motor in the PLT-HV, and supply air for the pneumatic controls on the PLT-HV.
  It is rated at 150 psi @ 300 cfm.
- **Heat-Exchanger:** In this first pass through it picks up heat from the compressor air, thereby cooling it somewhat, and uses it to later re-warm the air going to the gun.
- **After-cooler:** Lowers the compressed air temperature. The compressor air at the inlet of the after-cooler can be as high as 100° F above ambient. Upon exit from the after cooler it must be no higher than 122° F. Cooling is achieved by forcing cool ambient air to pass over the radiator. This unit is very similar to an automoble radiator and functions similarly. It needs power from the generator or other source.
- **Water separator and Pre filter:** Remove water and oil. Pre-filter has a differential pressure gauge (Delta P) to provide visual indication of filter clogging. The green range indicates from 0 to .35 bar and is the normal operating range. The red range indicates a clogged filter and the element must be changed before further operation.
- **Air Dryer:** Is a dual regenerative, desiccant filled dryer. Provides adsorption of moisture to less than -40° C dew point at a maximum of 152 psig (10.5 barg) and a minimum of 58 psig (4 barg) and between 99 and 1237 scfm. Desiccant is Dryfill ( Zeolite Molecular Sieve). The dryer is rated for continuos use. It is equipped with one inlet and two outlet pressure gauges (one for each column). Dryer has a moisture indicator which provides the unit with auto shut-off to prevent passing contaminated air.
- **After filter:** Prevent down steam dust carry over to PLT-HV. Canister is also fitted with a Delta P gauge and operates the same as the pre-filter.
- **Dew Point Monitor:** Provides moisture contamination reading and is measured as dew point. Unit range is from -40° to +15°F with an adjustable alarm set-point. The alarm is set at -35° F and will provide a visual and audible alarm when out of tolerance. It is physically mounted on the dessicant dryer and has its sensor mounted at the heat exchanger inlet for the final pass to the gun/nozzle.
- **Heat-Exchanger:** Re-warms the dry compressed air, reducing the moisture content in the PLT-HV delivery hoses and the nozzles.
- **PLT-HV:** Controls the air and $CO_2$ flow rates and pressure to the blast gun. Provides for visual confirmation of correct setting, emergency shut-off, pellet flow adjustment, and air pressure regulation to the blast nozzle. Unit contains the pellet storage and delivery hopper, AIR-LOCK pellet delivery motor, and the delivery hose connections.
- **Application Hoses:** 25 ft and 50 ft hose sections consists of (2) control actuator air hoses, (1) high pressure air hose, (1) dry ice pellet delivery hose, (1) #6 awg Static discharge wire, (1) protective sheath.
- **Application gun:** Provides operator with control of blast medium, via dead-man trigger, static/ directional control grip ring, which doubles as safety ring, and connection to insulated applicator "hot stick".
- **Application "hot sticks":** Provides connection from gun to directional nozzle while providing a safe working distance to the energized buss or L.I. switch.
- **Application nozzle:** Provides straight, 45°, and 90° angle direction control for blast medium. Attaches to hot sticks.
- **Generator:** Provides 120V power to the Dew Point Monitor and the After Cooler.

If other souce power is available, this unit will not have to be started. In fact, during this testing it was not used as site power was generally available.

# GENERAL PRECAUTIONS

***Seek immediate medical attention if exposed to any of the hazards described in A through E***

## A. ELECTRICAL HAZARDS

1. **ELECTRIC SHOCK -** Most industrial electrocutions result from contact with voltage source of sufficient magnitude. Influencing the effect of shock are factors such as duration of contact and current path. Secondary factors that affect the severity of electric shock are the person's age, physical condition, and size.

| Current (60 Hz) | Physiological Phenomena | Feeling or Lethal Incidence |
|---|---|---|
| <1 mA | | |
| 1 mA | | |
| 1-3 mA | | |
| 5 mA | | |
| | None | |
| 3-10 mA | Perception threshold | |
| 10 mA | | |
| | | Imperceptible |
| 30 mA | Paralysis threshold of arms | Mild sensation |
| | | Ground fault circuit interrupter |
| 75 mA | | (GCFI) |
| | | Painful sensation |
| 250 mA | Respiratory paralysis | Cannot release hand grip, if no grip, |
| | | victim may be thrown clear (may |
| | Fibrillation threshold 0.5 percent | progress to higher current and be |
| 4 A | | fatal) |
| | Fibrillation threshold 99 percent | Stoppage of breathing (frequently |
| | (>5 second exposure) | fatal) |
| | | Heart action discoordinated |
| | Heart paralysis threshold | (probably fatal) |
| >5A | (no Fibrillation) | |
| | | Heart stops for duration of current |
| | Tissue burning | passage. For short shocks, may |
| | | restart on interruption of current |
| | | (usually not fatal from heart |
| | | dysfunction) |
| | | Not fatal unless vital organs are |
| | | burned |

**2. THERMAL BURNS** - The heat generated by an electric arc can cause extremely bad burns and even death. The arc can reach temperatures from 15,000 °F up to four times the temperature of the sun's surface. The radiated thermal energy from an electric arc not only produces this extremely high heat, but also creates other damaging energy. At the time of a electrical fault, at least 80% of the thermal radiation is available to cause terrible burns. The temperature rise of skin must be limited to 46 °C in 0.1 sec for a curable burn.

**3. ARC BLAST** - While the vast majority of us are well aware of the dangers of electrocution, we often forget the extreme hazards of electric arc and blast. High-energy power sources can seriously injure electrical personnel when short circuits or electrical faults occur. When fault occurs, the available electrical energy at the fault location changes into other forms of energy. This energy, now in the form of an electrical arc, is usually very powerful and will typically result in high thermal radiation, damaging noise levels, explosive expansion of surrounding air, and vaporization/ splattering of conductors and metal components of the electrical equipment. **Maintain "2 foot 2" rule. for 15kv distribution.**

**4. STATIC DISCHARGE** - Because of high speed particle and air flows, static electricity may build up on different parts and discharge suddenly to the ground or the operator. To minimize static, make sure the equipment and work piece are clean and operable. Provide adequate footing and restraint for the operator to prevent secondary falls. **Beware - static discharge may ignite flammables.**

## B. COMPRESSED AIR (150 PSI)

***DANGER: Death or serious injury may occur inhaling compressed air.***

1. **FLYING OBJECTS/DEBRIS**
2. **WHIPPING HOSES**
3. **HIGH NOISES**

## C. EXTREME COLD TEMPERATURE (-110 °F) FROM $CO_2$ PELLETS

**1. DRY ICE BURNS** - Solid $CO_2$ is very cold (-110 °F) and quickly causes deep severe tissue burns on contact with skin. **Do not** handle $CO_2$ or cold equipment without proper insulating gloves.

**2. ASPHYXIATION FROM $CO_2$ (CONFINED SPACE ONLY)**
Sublimation of dry ice, whether during blasting or natural warming, forms $CO_2$ gas which may displace oxygen in low lying areas and enclosed spaces. Beware of entering these areas unless you are sure adequate ventilation has been provided. Adequate ventilation is necessary during $CO_2$ blasting and monitoring of the confined space may be necessary before re-entering.

## D. ROTATING AND MOVING PARTS

1. **COMPRESSOR ENGINE**
2. **GENERATOR**
3. **AFTER COOLER**
4. **PLT-HV**
5. **TRUCK LIFT-GATE**

## E. HOT SURFACES

1. **RADIATOR**
2. **GENERATOR**
3. **COMPRESSOR ENGINE EXHAUST**
4. **COMPRESSOR ENGINE/OUTLET AIR**

# PERSONAL PROTECTIVE EQUIPMENT.

| | $CO_2$ STICKMAN | HOSEMAN | PLT-HV OPERATOR | OBSERVERS |
|---|---|---|---|---|
| SAFETY ROPE | X | | | |
| KEVLAR FLASHCOAT | X | | | |
| NOMEX FLASHCOAT | | X | | |
| NOMEX COVERALLS | X | X | X | X |
| SAFETY GLASSES | | X | X | X |
| FACE SHIELD | X | | | |
| EAR PLUGS | X | X | X | X |
| EAR MUFFS | X | | | |
| NOMEX LINED GLOVES | X | | | |
| LEATHER GLOVES | | X | X | |
| HARD HAT | X | X | X | X |
| SAFETY SHOES | X | X | X | X |

# TRUCK EQUIPMENT.

## SAFETY EQUIPMENT:

Fire extinguisher
Fire Blanket
First Aid Kit
Radio equipment
Stepladder

Cones
Caution tapes
Test meters
Grounding straps

## OPERATIONAL EQUIPMENT:

Air Compressor
Hot stick, Nozzles, hoses
operating accessories
Dew Point Monitor
Dry Ice w/ container

Generator
PLT-HV
After Cooler, Dryer
HEAT Exchanger
Extension Cords

# SITE PRE-INSPECTION.

1. Accessibility to inside of LI switch ( removal of "Kirk"- locks or mechanical captive device).
2. Clearances:
   Walls - minimum of 4 ft. between the stickman and the target.
   Vehicles - no parking close to the pad/vault gate.
   Pedestrians - minimum of 15 ft. From the switch and 5 ft. from the service truck.
3. Housekeeping
   Pad cleaning
   Vegetation
4. Outage required
   Regular - requires 21 days
   Outage of Opportunity
5. Type of equipment
   Manufacturer
   Configuration (front/back doors)
6. Install safety signs, locks, and covers
7. Identify good grounds at site
8. Identify 120 vac source at site

# STANDARD OPERATING PROCEDURE.

## SITE INSPECTION AND PREPARATION.

1. Cordon the area/truck(5 ft. minimum) using cones and caution tape.
2. Establish grounds and clean off pad ground.
   a. ensure equipment on truck are grounded
   b. ground truck to pad and temp ground rod if more than 75 ft.
3. Set up equipment/connect hoses.

## BEFORE STARTING THE COMPRESSOR ENGINE.

1. CHECK THE OIL LEVEL.
2. CHECK THE FUEL.
3. CHECK THE WATER.
4. CHECK THE AIR FILTER SEDIMENT TRAP.
5. CHECK THE RADIATOR FOR ANY DEBRIS.
6. CHECK THE AWF OIL LEVEL.
7. CHECK THE FUEL FILTER SEDIMENT TRAP.
8. PROVIDE 120 VAC SOURCE TO AFTER COOLER UNIT AND DEW POINT MONITOR.
9 ENSURE HIGH PRESSURE DISCHARGE VALVE FROM THE COMPRESSOR, INLET & OUTLET VALVE FROM THE DRYER, AND OUTLET VALVE TO PLT - HV ARE CLOSED.
10. ENSURE ALL AIR HOSES AND ITS RESTRAINT ARE CONNECTED.
11. CRACK OPEN SERVICE LINE (*Green Handle*).
12. FILL-IN LOG ENTRY.

## STARTING THE ENGINE.

*WARNING : WHEN RESTARTING THE COMPRESSOR, MAKE SURE RECEIVER TANK PRESSURE HAS BLOWN DOWN TO 10 PSIG OR LESS. MORE THAN 10 PSIG CAN PUT EXTRA LOAD ON THE STARTER.*

1. TURN IGNITION SWITCH TO "ON" POSITION.
2. PUSH THE OVERRIDE & START BUTTON. AS ENGINE ENGAGES, RELEASE THE START BUTTON, BUT HOLD THE OVERRIDE BUTTON UNTIL ENGINE OIL PRESSURE REACHES 20 PSIG, THEN RELEASE.
3. CLOSE SERVICE LINE VALVE (*Green Handle*).
4. ALLOW FOR SUFFICIENT WARM UP OF MACHINE FOR 5 MIN. BEFORE SHIFTING TO HIGH POSITION.
5. AFTER WARM UP, PUSH IDLE WARM-UP BUTTON TO "RUN".
6. TURN ON POWER TO AFTER COOLER MOTOR.
7. TURN DEW POINT MONITOR SWITCH TO "ON" POSITION.
8. SLOWLY OPEN HIGH PRESSURE DISCHARGE VALVE UNTIL FULLY OPENED.
9. SLOWLY OPEN INLET VALVE UNTIL FULLY OPENED (*Yellow Handle*).
10. CHECK THE DIFFERENTIAL PRESSURE AT THE PRE-FILTER UNIT, ENSURE THE GAUGE READS BETWEEN 0-0.35 BAR (Green Zone).
11. SLOWLY OPEN OUTLET VALVE UNTIL FULLY OPENED (*Green Handle*).

## STARTING THE PLT-HV.

1. HOOK-UP AIR SUPPLY, GUN, AND TRIGGER LINES TO MACHINE.
2. HOOK-UP RETRACTABLE WIRE GROUND TO A GOOD EARTH GROUND.
3. TURN VENT-RUN SELECTOR TO "RUN", THEN TURN THE RUN-EMPTY SWITCH SELECTOR TO "RUN".
4. PUSH E-STOP TO "OFF" AND TURN ON THE AIR SUPPLY. (*NOTE: CHECK FOR LEAKS AND DAMAGE HOSES.*)
5. ADD CO2 PELLETS TO HOPPER. (*ENSURE SAFETY GRID IS IN PLACE AND INTERLOCK SPRING IS COMPRESSED.)*
6. CHECK INSTRUMENT AIR PRESSURE, IT MUST BE 75-90 PSI.
7. SET BLAST PRESSURE AT 80 PSI AND CO2 PELLET FEED RATE AT 60 PSI. (*NOTE: BLAST PRESSURE MUST BE AT LEAST 20 PSI OR MACHINE WILL NOT OPERATE.)*
8. PULL THE E-STOP BUTTON TO THE "ON" POSITION, THEN PUSH THE "ARM/RESET" BUTTON.
9. THE BLAST GUN TRIGGER IS NOW ARMED AND BLASTING CAN BEGIN.

# CLEANING PROCESS

## LI SWITCHES.

1. Perform Ultrasound test to detect any sign of tracking.
2. Open access doors.
3. Inspect for loose materials, connections, barriers, secondary wires and rust.
4. Check heaters for proper operation.
5. Start $CO_2$ cleaning from the bottom to the middle portion and then top to middle portion of the switch.
6. Secure access to the equipment.
7. Repeat Ultrasound test on the switch.
8. Secure $CO_2$ cleaning.

## ENGINE SHUTDOWN.

1. SHIFT SWITCH FROM HIGH TO LOW.
2. CLOSE ALL VALVES, HIGH PRESSURE DISCHARGE, OUTLETS AND INLET
3. LET THE ENGINE RUN FOR 5 MINUTES, THEN TURN THE IGNITION SWITCH TO "OFF" POSITION.
4. SLOWLY OPEN THE SERVICE LINE VALVE TO RELIEVE AIR PRESSURE.
5. TURN DEW POINT MONITOR TO "OFF" POSITION.
6. TURN OFF POWER TO AFTER COOLING MOTOR.

## PLT-HV STOP/SHUT DOWN.

1. RELEASE GUN TRIGGER.
2. PUSH E-STOP TO "OFF" TO LOCK OUT THE TRIGGER.

## FOR EXTENDED STORAGE OVER 30 MIN.

1. EMPTY THE PELLETS FROM THE HOPPER.
2. TURN OFF THE AIR SUPPLY AT THE SOURCE.
3. TO BLEED OFF THE HIGH PRESSURE AIR IN THE SUPPLY HOSES AND AIR LINES, SELECT THE "VENT" POSITION ON THE VENT-RUN SWITCH.
4. AFTER THE AIR HAS FINISHED VENTING, DISCONNECT HOSES.

# APPENDIX E

## CO2 SYSTEM CLEANING TEST RESULTS

- DATA SHEETS OF TEST RESULTS
- NOISE SURVEY RESULTS
- HIGH VOLTAGE LEAKAGE TEST RESULTS

DATE 10/30/97

TEST # 1

L.I. SWITCH ID
FPE FEDERAL PACIFIC
NEWARK, N.J. - 13.8KV

INTERLOCK ON/OFF
KIRK LOCK PREVIOUSLY REMOVED

ARRIVE SITE TIME 1038

DEPART SITE TIME 1220 (SECURE-LUNCH)

START CLEAN TIME 1151

FINISH CLEAN TIME 1209

BEFORE CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)

VISUAL - MINOR DUST, DIRT
ULTRASOUND - NO TRACKING INDICATED

COMPRESSOR DATA

DIESEL START TIME N/A hr

DIESEL FINISH TIME N/A hr

OUTLET AIR TEMP 200 $^0$F

OUTLET AIR PRESSURE 150 psi

DEW POINT ALARM SET -40 $^0$F

DIESEL FUEL USED

7 gal/hr x N/A hr = N/A gal (SEE TEST # 2)

PLT DATA

BLAST AIR PRESSURE 75 psi

$CO_2$ FEED PRESSURE 60 psi

$CO_2$ FEED RATE 3 lb/min

HOUR METER START 4.7 hr

HOUR METER FINISH 4.9 hr

TOTAL PLT TIME 0.2 hr

AFTER CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)

VISUAL - DUST/DIRT REMOVED. COMPONENTS OF SWITCH ASSEMBLY APPEARED CLEAN

ULTRASOUND - NO TRACKING INDICATED.

PAD/GENERATOR POWER USED PAD

OPERATOR - STICKMAN RICHARD JUAREZ

OPERATOR - HOSEMAN LOUIS BANNISTER

OPERATOR - PLT ROLANDO ROSAL

MISC. NOTES ( NOZZLES USED, PROBLEMS, ETC. )

USED STRAIGHT AND 90° NOZZLE TIPS.
CREW INSTALLED HANDLES TO AID IN REMOVAL OF L.I. BACK PANELS. CREW NOTED 90° NOZZLE MORE DIFFICULT TO HANDLE, BUT MANAGEABLE. SOME INTERMITTENT OPERATION OF AIR/$CO_2$ GUN WHEN TRIGGER ENGAGED. CAUSE UNKNOWN. NUMEROUS STARTS AND STOPS DURING CLEANING AS CREW BECAME FAMILIAR WITH PROCESS.
OBSERVER - LARRY BRADY, OSH OFFICE OF PWC TOOK SOUND LEVEL MEASUREMENTS AT THIS SITE.

DATE 10/30/97

TEST # 2

**L.I. SWITCH ID**
FPE FEDERAL PACIFIC
NEWARK, N.J. - 13.8KV

**INTERLOCK ON/OFF**
KIRK LOCK PREVIOUSLY
REMOVED

ARRIVE SITE TIME 1315

DEPART SITE TIME 1425

START CLEAN TIME 1344

FINISH CLEAN TIME 1355

**BEFORE CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)**
VISUAL - MOSTLY CLEAN, MINOR DUST
ULTRASOUND - NO TRACKING INDICATED

**COMPRESSOR DATA**

DIESEL START TIME N/A hr

DIESEL FINISH TIME N/A hr

OUTLET AIR TEMP 200 $^0$F

OUTLET AIR PRESSURE 150 psi

DEW POINT ALARM SET -40 $^0$F

DIESEL FUEL USED

**PLT DATA**

BLAST AIR PRESSURE 70 psi

$CO_2$ FEED PRESSURE 56 psi

$CO_2$ FEED RATE 2.8 lb/min

HOUR METER START 4.9 hr

HOUR METER FINISH 5.1 hr

TOTAL PLT TIME 0.2 hr

7 gal/hr x 2.5 hr = 17.5 gal (INCLUDES FUEL FOR TEST #1)

**AFTER CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)**
VISUAL - CLEAN
ULTRASOUND - NO TRACKING INDICATED

PAD/GENERATOR POWER USED PAD

OPERATOR - STICKMAN LOUIS BANNISTER

OPERATOR - HOSEMAN RICHARD JUAREZ

OPERATOR - PLT ROLANDO ROSAL

**MISC. NOTES ( NOZZLES USED, PROBLEMS, ETC. )**
USED 45° NOZZLE. SAME TYPE L.I. SWITCH AS TEST #1.
CONTINUED INTERMITTENT OPERATION OF AIR/CO2 GUN WHEN TRIGGER DEPRESSED. AIR FLOW LOST. SUSPECTED PLT UNIT AT FIRST, BUT LATER (AFTER SWITCH CLEANED), DISCOVERED THAT TRIGGER ASSEMBLY NEEDED ADJUSTMENT.
OBSERVER - ALAN WILSON, PWC ENVIRONMENTAL DIVISION
RETURNED TRUCK TO STORAGE YARD ≈ 1500.

DATE 11/19/97

TEST # 3

**L.I. SWITCH ID**

INDUSTRIAL ELECTRIC MFG., INC.
FREMONT, CA.
13.8 KV

**INTERLOCK ON/OFF**

PREVIOUSLY REMOVED BY GRINDING NUTS OFF KIRK LOCK AND REMOVING FROM FRONT PANEL

ARRIVE SITE TIME 1000

DEPART SITE TIME 1120

START CLEAN TIME 1030

FINISH CLEAN TIME 1055

**BEFORE CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)**

VISUAL - SOME DIRT/CONTAMINATION ON PORCELIN INSULATORS AND CABLES.
ULTRASOUND - NOT USED

**COMPRESSOR DATA**

DIESEL START TIME 7.0 hr

DIESEL FINISH TIME 8.2 hr

OUTLET AIR TEMP 185 $^0$F

OUTLET AIR PRESSURE 140 psi

DEW POINT ALARM SET -40 $^0$F

DIESEL FUEL USED

7 gal/hr x 1.2 hr = 8.4 gal

**PLT DATA**

BLAST AIR PRESSURE 65 psi

$CO_2$ FEED PRESSURE 55 psi

$CO_2$ FEED RATE 2.7 lb/min

HOUR METER START 5.1 hr

HOUR METER FINISH 5.3 hr

TOTAL PLT TIME 0.2 hr

**AFTER CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)**

VISUAL - VERY CLEAN - CREW CONSENSUS
ULTRASOUND - NOT USED

PAD/GENERATOR POWER USED PAD

OPERATOR - STICKMAN RICHARD JUAREZ

OPERATOR - HOSEMAN LOUIS BANNISTER

OPERATOR - PLT ROLANDO ROSAL

**MISC. NOTES ( NOZZLES USED, PROBLEMS, ETC. )**

USED 45° AND 90° NOZZLES. BACK PANEL L.I. SWITCH REMOVED A TO CLEAN. USED 90° NOZZLE IN TIGHT SPOTS, AND REDUCED AIR PRES TO 50 PSI TO MAKE IT EASIER TO CONTROL HOTSTICK/GUN. TO CLE A PERSISTENT DIRTY SPOT, USED STRAIGHT NOZZLE AND INCREASED AIR TO 80 PSI. AVOIDED TOP INSULATORS COVERED WITH PROTECTIVE SILICONE GREASE. THIS TYPE NOT AVAILABLE FOR $CO_2$ CLEANING.
OBSERVERS - RUSS LAWLER, KEN MICKLE - ALPHEUS CLEANING TECHNOL

DATE 11/20/97

TEST # 4

L.I. SWITCH ID

FC-20 L.I. SWITCHBOARD
ITE IMPERIAL CORP.
GREENSBURG, PA.
13.8 KV

INTERLOCK ON/OFF KIRK LOCK REMOVED ON PREVIOUS OUTAGE OF OPPORTUNITY.

ARRIVE SITE TIME 0800

DEPART SITE TIME 0910

START CLEAN TIME 0838

FINISH CLEAN TIME 0852

BEFORE CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)

VISUAL - DIRTY FUSES INSIDE L.I. BOX. OTHER MINOR DUST
ULTRASOUND - NO TRACKING INDICATED

COMPRESSOR DATA

DIESEL START TIME 8.2 hr

DIESEL FINISH TIME 8.9 hr

OUTLET AIR TEMP 175 °F

OUTLET AIR PRESSURE 140 psi

DEW POINT ALARM SET -40 °F

DIESEL FUEL USED

7 gal/hr x 0.7 hr = 4.9 gal

PLT DATA

BLAST AIR PRESSURE 50/65 psi

$CO_2$ FEED PRESSURE 55/65 psi

$CO_2$ FEED RATE 2.7/3.2 lb/min

HOUR METER START 5.3 hr

HOUR METER FINISH 5.5 hr

TOTAL PLT TIME 0.2 hr

AFTER CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)

VISUAL - CLEAN
ULTRASOUND - NO TRACKING INDICATED

PAD/GENERATOR POWER USED PAD

OPERATOR - STICKMAN LOUIS BANNISTER

OPERATOR - HOSEMAN RICHARD JUAREZ

OPERATOR - PLT ROLANDO ROSAL

MISC. NOTES ( NOZZLES USED, PROBLEMS, ETC. )

L.I. SITE NEAR PAINT SHOP, USED 90° AND 45° NOZZLES. LEFT PLT UNIT ON TRUCK AND USED LONG HOSES TO REACH L.I. THIS WOULD BECOME SOP. BACK PANELS OF L.I. EASILY REMOVED. INCREASED AIR PRESSURE AND ICE FLOW NEAR END OF JOB TO CLEAR PLT UNIT OF ICE FOR TRAVEL TO NEXT SITE.

DATE 11/20/97

TEST # 5

**L.I. SWITCH ID**
G.E. L.I. SWITCH
PHILADELPHIA, PA.
TYPE SE 260S
13.8 KV

**INTERLOCK ON/OFF**
KIRK LOCK PREVIOUSLY
REMOVED

ARRIVE SITE TIME 0930

DEPART SITE TIME 1030

START CLEAN TIME 1000

FINISH CLEAN TIME 1010

**BEFORE CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)**

VISUAL - NOT TOO DIRTY, SOME DUST AND UNKNOWN SPOTS.
ULTRASOUND - SOME MINOR TRACKING NOISE INDICATED
COULD NOT PINPOINT SOURCE

**COMPRESSOR DATA**

DIESEL START TIME 8.9 hr

DIESEL FINISH TIME 9.5 hr

OUTLET AIR TEMP 180 °F

OUTLET AIR PRESSURE 150 psi

DEW POINT ALARM SET -40 °F

DIESEL FUEL USED

7 gal/hr x 0.6 hr = 4.2 gal

**PLT DATA**

BLAST AIR PRESSURE 55 psi

$CO_2$ FEED PRESSURE 65 psi

$CO_2$ FEED RATE 3.2 lb/min

HOUR METER START 5.5 hr

HOUR METER FINISH 5.6 hr

TOTAL PLT TIME 0.1 hr

**AFTER CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)**

VISUAL - CLEAN, DUST AND SPOTS REMOVED
ULTRASOUND - NO TRACKING INDICATED

PAD/GENERATOR POWER USED PAD

OPERATOR - STICKMAN RICHARD SUAREZ

OPERATOR - HOSEMAN LOUIS BANNISTER

OPERATOR - PLT ROLANDO ROSAL

**MISC. NOTES ( NOZZLES USED, PROBLEMS, ETC. )**

SITE LOCATED NEAR WATER, PAST PIER 2. USED 45° NOZZLE AND (3) FOOT HOT STICK. BACK PANEL OF L.I. OPENS EASILY AFTER REMOV[ING] HOLDING NUTS. PANEL SWINGS OPEN.

ALSO CLEANED A VOLTAGE REGULATOR LOCATED IN BOX ADJACENT TO L.I. SWITCH.

DATE 11/20/97

TEST # 6

**L.I. SWITCH ID**

WESTINGHOUSE WLI SWITCH
WESTINGHOUSE ELECTRIC CORP.
CINCINNATI, OHIO
13.8 KV

**INTERLOCK ON/OFF**

PREVIOUSLY REMOVED DURING OUTAGE WHEN PIER NOT OCCUPIED. MECHANICAL TYPE LOCK.

ARRIVE SITE TIME 1204

DEPART SITE TIME 1315

START CLEAN TIME 1230

FINISH CLEAN TIME 1253

**BEFORE CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)**

VISUAL - MODERATE DIRTY INSULATORS AND INSIDE METAL BOX
ULTRASOUND - SLIGHT TRACKING NOISE ON FRONT SIDE L.I.

| COMPRESSOR DATA | | PLT DATA | |
|---|---|---|---|
| DIESEL START TIME | 9.2 hr | BLAST AIR PRESSURE | 100/150 psi |
| DIESEL FINISH TIME | 10.2 hr | $CO_2$ FEED PRESSURE | 55 psi |
| OUTLET AIR TEMP | 160 $^0$F | $CO_2$ FEED RATE | 2.7 lb/min |
| OUTLET AIR PRESSURE | 140 psi | HOUR METER START | 5.7 hr |
| DEW POINT ALARM SET | -40 $^0$F | HOUR METER FINISH | 5.9 hr |
| DIESEL FUEL USED | | TOTAL PLT TIME | 0.2 hr |

7 gal/hr x 1.0 hr = 7.0 gal

**AFTER CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)**

VISUAL - CLEAN INSULATORS AND BOX
ULTRASOUND - NO TRACKING INDICATED

PAD/GENERATOR POWER USED PAD

OPERATOR - STICKMAN ROLANDO ROSAL

OPERATOR - HOSEMAN LOUIS BANNISTER

OPERATOR - PLT RICHARD JUAREZ

**MISC. NOTES ( NOZZLES USED, PROBLEMS, ETC. )**

SITE ON END OF PIER 2. USED 45° NOZZLE AND (3) FOOT HOTSTICK. BACK PANEL REMOVED WITH (20) NUT FASTENERS. ACCESS RESTRICTED DUE TO CHAIN LINK FENCE PROXIMITY, 4-5 FEET AWAY. AT START OF CLEANING, THE BLAST AIR PRESSURE INCREASED TO 150PSI AND COULD NOT BE REDUCED USING THE PLT CONTROLS. SYSTEM WAS SHUT DOWN FOR INSPECTION. IT WAS FOUND THE PLT OPERATOR HAD OPENED THE WRONG VALVE (BYPASS) ON PLT UNIT, ALLOWING FULL AIR PRESSURE TO GUN. SYSTEM WAS RESET, AND VALVE RED-TAGGED FOR FUTURE OPERATION TO AVOID PROBLEM. NO HARM TO SYSTEM.

DATE 11/20/97

TEST # 7

**L.I. SWITCH ID**

GENERAL ELECTRIC CO.
PHILADELPHIA, PA.
S.O. NO. C2956A
13.8KV

**INTERLOCK ON/OFF**

KIRK LOCK PREVIOUSLY REMOVED WHEN PIER NOT OCCUPIED

ARRIVE SITE TIME 1325

DEPART SITE TIME 1425

START CLEAN TIME 1358

FINISH CLEAN TIME 1411

**BEFORE CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)**

VISUAL- MODERATE DIRT & DUST ON FUSES AND INSULATORS
ULTRASOUND - VERY SLIGHT TRACKING NOISE ON FRONT SIDE

**COMPRESSOR DATA**

DIESEL START TIME 10.2 hr

DIESEL FINISH TIME 10.7 hr

OUTLET AIR TEMP 185 °F

OUTLET AIR PRESSURE 150 psi

DEW POINT ALARM SET -40 °F

DIESEL FUEL USED

7 gal/hr x 0.5 hr = 3.5 gal

**PLT DATA**

BLAST AIR PRESSURE 50 psi

$CO_2$ FEED PRESSURE 55 psi

$CO_2$ FEED RATE 2.7 lb/min

HOUR METER START 5.9 hr

HOUR METER FINISH 6.1 hr

TOTAL PLT TIME 0.2 hr

**AFTER CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)**

VISUAL - CLEAN INSULATORS, FUSES, AND BOX
ULTRASOUND - NO TRACKING INDICATED

PAD/GENERATOR POWER USED PAD

OPERATOR - STICKMAN LOUIS BANNISTER

OPERATOR - HOSEMAN RICHARD JUAREZ

OPERATOR - PLT ROLANDO ROSAL

**MISC. NOTES ( NOZZLES USED, PROBLEMS, ETC. )**

SITE ON PIER 3 SERVING SHIP POWER. USED 6 FOOT STICK WI 45° NOZZLE. BACK REMOVED BY [redacted] METAL SCREWS. BACK ACCES LIMITED BY OTHER UNITS, HENCE L.I. CLEANED FROM FRONT SIDE ONLY, WHICH SEEMED ADEQUATE. THIS L.I. SWITCH WAS QUITE TALL AND MOUNTED ON A CONCRETE PAD. THE SIX FOOT HOT STICK WAS REQUIRED TO REACH THE UPPER AREAS.

DATE 11/21/97

TEST # 8

**L.I. SWITCH ID**
TEST INSULATOR.
STRAIGHT SIDED
PLASTIC TYPE-GREY

**INTERLOCK ON/OFF**
N/A

ARRIVE SITE TIME AT PWC SHOP

DEPART SITE TIME AT PWC SHOP

START CLEAN TIME 1000

FINISH CLEAN TIME 1012

**BEFORE CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)**

VISUAL - DIRTY CONTAMINATED INSULATOR - SEE NOTES BELOW
HIGH VOLTAGE TESTS - 5KV, 6 MAMP LEAKAGE CURRENT
(PRODUCED SOME ARC TRACKING) 12KV, 20 MAMP " "
40KV, 60 MAMP " "
MA = (MILLIAMPS)

**COMPRESSOR DATA**

DIESEL START TIME 10.7 hr

DIESEL FINISH TIME 11.5 hr

OUTLET AIR TEMP 180 $^0$F

OUTLET AIR PRESSURE 150 psi

DEW POINT ALARM SET -40 $^0$F

DIESEL FUEL USED

7 gal/hr x 0.8 hr = 5.6 gal

**PLT DATA**

BLAST AIR PRESSURE 56 psi

$CO_2$ FEED PRESSURE 55 psi

$CO_2$ FEED RATE 2.7 lb/min

HOUR METER START 6.2 hr

HOUR METER FINISH 6.3 hr

TOTAL PLT TIME 0.1 hr

**AFTER CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)**

VISUAL - INSULATOR CLEANER, SOME ARC SPOTS
HIGH VOLTAGE TESTS - 15KV, 0.2 MAMP LEAKAGE CURRENT
30KV, 0.1 MAMP " "

PAD/GENERATOR POWER USED PAD

OPERATOR - STICKMAN RICHARD JUAREZ

OPERATOR - HOSEMAN LOUIS BANNISTER

OPERATOR - PLT ED DURLAK

**MISC. NOTES ( NOZZLES USED, PROBLEMS, ETC. )**

THESE TESTS CONDUCTED IN THE PWC YARD AREA USED INSULATORS THAT WERE CONTAMINATED WITH A MIXTURE OF EGG WHITES, MILK, SUGAR, MOLASSES, AND NO-LOX GREASE. USED 6 FOOT HOTSTICK, 45° NOZZLE.

DATE 11/21/97

TEST # 9

**L.I. SWITCH ID**

TEST INSULATOR
WHITE PORCELIN
SKIRTED SIDES

**INTERLOCK ON/OFF**

N/A

ARRIVE SITE TIME AT PWC SHOP

DEPART SITE TIME AT PWC SHOP

START CLEAN TIME 1027

FINISH CLEAN TIME 1032

**BEFORE CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)**

VISUAL - DIRTY CONTAMINATED INSULATOR - SEE NOTES BELOW
HIGH VOLTAGE TESTS - 20KV - PRODUCED 80 MA LEAKAGE CURRENT
- 40KV - PRODUCED 80 MA " "
ELECTRICAL ARC TRACKING OCCURRED AT BOTH VOLTAGES.
MA=(MILLIAMPS)

**COMPRESSOR DATA**

DIESEL START TIME 10.7 hr

DIESEL FINISH TIME 11.5 hr

OUTLET AIR TEMP 180 °F

OUTLET AIR PRESSURE 150 psi

DEW POINT ALARM SET -40 °F

DIESEL FUEL USED

7 gal/hr x 0.8 hr = 5.6 gal

**PLT DATA**

BLAST AIR PRESSURE 55 psi

$CO_2$ FEED PRESSURE 55 psi

$CO_2$ FEED RATE 2.7 lb/min

HOUR METER START 6.3 hr

HOUR METER FINISH 6.4 hr

TOTAL PLT TIME 0.1 hr

**AFTER CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)**

VISUAL - INSULATOR CLEANER, SOME ARC SPOTS
HIGH VOLTAGE TESTS - 15KV - PRODUCED 0.2-0.4 LEAKAGE CURRENT, MA
- 30KV - PRODUCED 0.2MA. " "
ELECTRICAL ARCS DID NOT OCCUR

PAD/GENERATOR POWER USED PAD

OPERATOR - STICKMAN RICHARD JUAREZ

OPERATOR - HOSEMAN LOUIS BANNISTER

OPERATOR - PLT ED DURLAK

**MISC. NOTES ( NOZZLES USED, PROBLEMS, ETC. )**

THIS TEST CONDUCTED IN THE PWC YARD AREA USED AN INSULATOR CONTAMINATED WITH A MIXTURE OF EGG WHITES, MILK, SUGAR, MOLASSES, AND NO-LOX GREASE. USED 6 FOOT HOT STICK AND 45° NOZZLE.

DATE 11/21/97

TEST # 10

L.I. SWITCH ID
TEST INSULATOR
BLACK PLASTIC
STRAIGHT SIDES

INTERLOCK ON/OFF
N/A

ARRIVE SITE TIME AT PWC SHOP

DEPART SITE TIME AT PWC SHOP

START CLEAN TIME 1045

FINISH CLEAN TIME 1052

BEFORE CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)
VISUAL - MODERATE DUST DUE TO STORAGE IN PWC YARD
HIGH VOLTAGE TEST - 15KV - NO DETECTABLE LEAKAGE CURRENT

COMPRESSOR DATA

DIESEL START TIME 10.7 hr

DIESEL FINISH TIME 11.5 hr

OUTLET AIR TEMP 180 $^0$F

OUTLET AIR PRESSURE 150 psi

DEW POINT ALARM SET -40 $^0$F

DIESEL FUEL USED

7 gal/hr x 0.8 hr = 5.6 gal

PLT DATA

BLAST AIR PRESSURE 55 psi

$CO_2$ FEED PRESSURE 55 psi

$CO_2$ FEED RATE 2.7 lb/min

HOUR METER START 6.4 hr

HOUR METER FINISH 6.5 hr

TOTAL PLT TIME 0.1 hr

AFTER CLEANING CONDITION(VISUAL, ULTRASOUND, ETC)
VISUAL - CLEAN
HIGH VOLTAGE TEST - 15KV - NO LEAKAGE CURRENT PRODUCED

PAD/GENERATOR POWER USED PAD

OPERATOR - STICKMAN RICHARD JUAREZ

OPERATOR - HOSEMAN LOUIS BANNISTER

OPERATOR - PLT ED DURLAK

MISC. NOTES ( NOZZLES USED, PROBLEMS, ETC. )
THIS TEST CONDUCTED IN THE PWC YARD AREA USED AN INSULATOR THAT HAD BEEN STORED IN THE YARD. IT WAS NOT CONTAMINATED WITH THE MIXTURE OF TESTS 9 AND 10. IT HAD A MODERATE LAYER OF DUST DUE TO YARD STORAGE. USED 6 FOOT HOT STICK AND 45° NOZZLE. USED AS A CONTROL TEST FOR COMPARISON WITH TESTS 8 AND 9.

# INDUSTRIAL HYGIENE NOISE SURVEY FORM

Date: 30 OCT 97

Survey #: 97 - 1348 Activity: PWC UIC: 63387

Building: Outside 20 Location: NAVSTA Shop: 622

Area Posted: ☐ Yes ☒ No

Hearing Protection in Use: ☒ Yes ☐ No

Sound Level Meter Results:

| | | | | | |
|---|---|---|---|---|---|
| Source Description | sullair compressor | Nozzle, blasting | Nozzle, ASSISTANT 8' from nozzle | | |
| Machine #/USN # | 123826 | — | — | | |
| Noise Pattern<br>C = Continous<br>IN = Intermittent<br>IM = Impulse/Impact | C<br>IN<br>IM | C<br>IN<br>IM | C<br>IN<br>IM | C<br>IN<br>IM | C<br>IN<br>IM |
| Equipment Labeled | Yes<br>No | Yes<br>No | Yes<br>No | Yes<br>No | Yes<br>No |
| Noise radius (ft) | idle run<br>4 - 14 | 30ft | | | |
| Meter Response<br>F = Fast<br>S = Slow<br>I = Impulse/Impact | F<br>S<br>I | F<br>S<br>I | F<br>S<br>I | F<br>S<br>I | F<br>S<br>I |
| Results/dBA<br>dB Peak | idle run<br>90 - 98 | 105 - 106 | 97 - 99 | | |

Exposed Employees: ☐ Yes (Attach Roster) ☐ No

Comments: Single hearing protection is required above 84dBA. Double protection is required above 104dBA. The nozzle operator requires double protection. The assistant requires single protection. Hearing protection is required within 30 ft of the nozzle and 14ft of the compressor.

| Sound Level Meter Results | | | | | |
|---|---|---|---|---|---|
| Source Description | | | | | |
| Machine #/USN # | | | | | |
| Noise Pattern<br>C = Continous<br>IN = Intermittent<br>IM = Impulse/Impact | C<br>IN<br>IM | C<br>IN<br>IM | C<br>IN<br>IM | C<br>IN<br>IM | C<br>IN<br>IM |
| Equipment Labeled | Yes<br>No | Yes<br>No | Yes<br>No | Yes<br>No | Yes<br>No |
| Noise radius (ft) | | | | | |
| Meter Response<br>F = Fast<br>S = Slow<br>I = Impulse/Impact | F<br>S<br>I | F<br>S<br>I | F<br>S<br>I | F<br>S<br>I | F<br>S<br>I |
| Results/dBA<br>dB Peak | | | | | |

| SOUND LEVEL METER | | MICROPHONE | | CALIBRATOR | |
|---|---|---|---|---|---|
| Mfg QuesT | | Mfg | | Mfg QuesT. | |
| Model 215 | Serial # MOB4CC79 | Model | Serial # | Model CA-12 | Serial # 43080C69 |
| Last Electroacoustic Calib. Date 9/11/97 | | Last Electroacoustic Calib. Date | | Last Electroacoustic Calib. Date 9/9/97 | |

Field Calibration Performed: Pre Calibration Date: 10/30/97

Post Calibration Date: 10/30/97

Calibration OK: ☒ Yes ☐ No

Measurements Obtained: ☐ Indoors ☒ Outdoors Wind Screen: ☒ Used ☐ Not Used

Surveyed by: Laurence L. Brady Date: 30 OCT 97

*Reviewed by: ______ Date: ______

*BY MY SIGNATURE, I VERIFY THAT I HAVE REVIEWED THIS FORM FOR COMPLETENESS AND ACCURACY AND THAT THE WORK DOCUMENTED HEREON WAS CONDUCTED AND RECORDED IN ACCORDANCE WITH NAVY INSTRUCTIONS, FEDERAL REGULATIONS, AND/OR ACCEPTED INDUSTRIAL HYGIENE PROCEDURES.