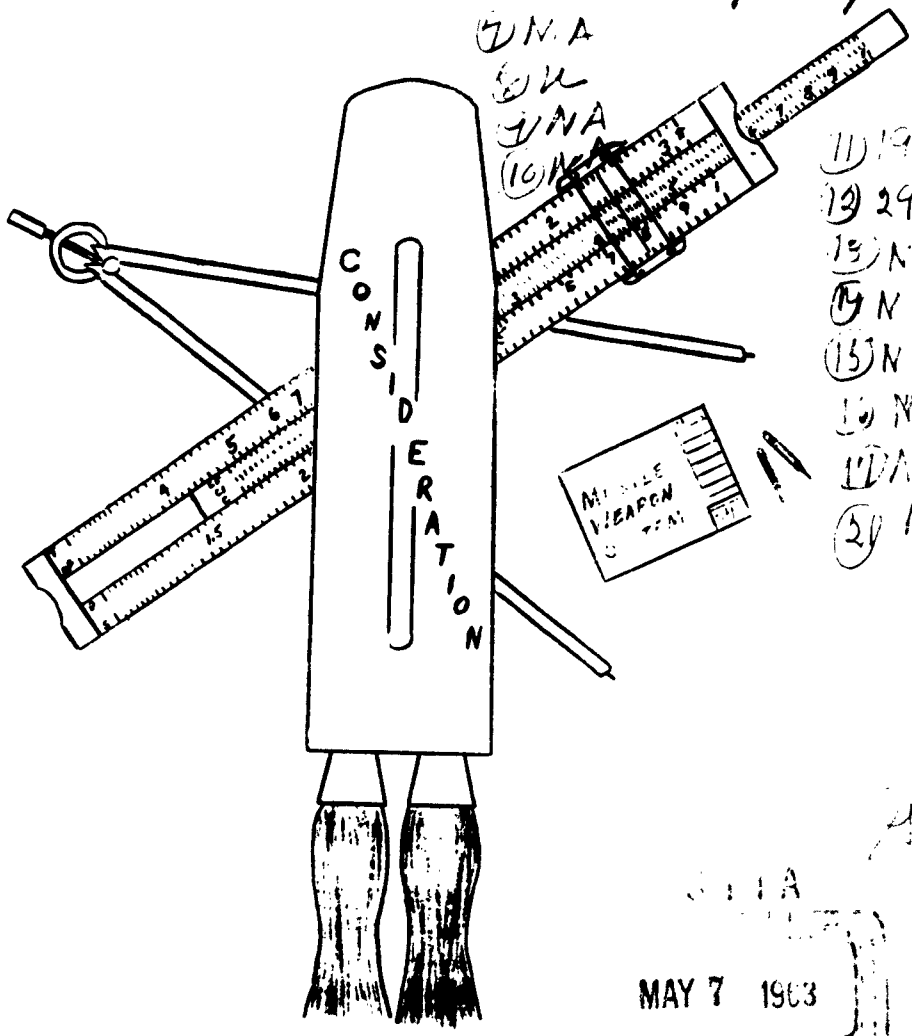
DESIGN BRIEFS

(6) Design Consideration Briefs, Missile Weapon System



PREFACE

~~This initial publication of Design Consideration Briefs was compiled in the Missile Safety Division, Directorate of Aerospace Safety. These Briefs are not in detail and are not intended to be the only method by which any cited deficiencies may be corrected.~~ These briefs were prepared to highlight some design considerations which have or could jeopardize the safety of missile personnel and equipment. The Briefs should be of special interest to the designer who does not have the opportunity to keep himself well informed on current operational and maintenance concepts and problems associated with missile systems. If industry and government agencies' response is favorable to the usefulness of this document, action will be taken to assure periodic publication of pertinent Design Consideration Briefs. To assist in the follow-on evaluation special attention is directed to the request for comments contained in the Introduction of this publication.

Jay T. Robbins

JAY T. ROBBINS
Brig Gen, USAF
Director, Aerospace Safety

TABLE OF CONTENTS

* M - Mechanical E - Electrical C - Chemical

		Related Areas *
63-M-16	Hydrocarbon Fluid Drip Pans in LOX area	- - - - - C
63-M-17	Storage of Work Platform Safety Rails	
63-M-18	Calibration of System Components	- - - - - C & E
63-M-19	Missile Protection during Lift Operation	- - - - - C

ELECTRICAL SECTION

63-E-1	Exposed Electrical Terminals	
63-E-2	RF Protection for EEDs	
63-E-3	Protection against Short Circuits	
63-E-4	Compromised Reliability, Control and Power Lines	
63-E-5	Electrical Connector Keyway Design	
63-E-6	Sequential Multi-Switch Operation for Critical Circuits	
63-E-7	Shock Hazard at Connectors when Large Filter Capacitors retain Charge	
63-E-8	Current Leakage through Multiple Ground Contacts	
63-E-9	Dissimilar Metals	- - - - - M
63-E-10	Electrical Connector Installation with respect to Moisture	- - - - - M
63-E-11	Pin to Case Dielectric Strength for EEDs	
63-E-12	Location of Signal and Power Wires	

CHEMICAL SECTION

63-C-1	Solid Rocket Motor Temperature and Moisture Limitations	

* M - Mechanical E - Electrical C - Chemical

		Related Areas *
63-C-2	Non-LOX Campatible Materials Located in LOX Handling Areas	- - - - - M
63-C-3	Hydrazine Tank Burst Diaphragm Leaking	- - - - -
63-C-4	Fuel Expulsion Diaphragm	
63-C-5	Drain Valves in Liquid Systems	- - - - - M
63-C-6	Chemical Vapor Detection Systems	
63-C-7	Contamination by Internal Failure of Propellant Loading Systems	- - - - - M
63-C-8	Missile Propellant Tank Loading and Liquid Level Control Instrumentation	- - - - - M
63-C-9	Reverse Flow Filters	- - - - - M
63-C-10	Separate Routing of Fuel and Oxidizer Lines	- - - - - M

* M - Mechanical E - Electrical C- Chemical

PURPOSE

The purpose of this document is to highlight significant design considerations that would compromise safety and operational objectives of missile/space systems and related areas.

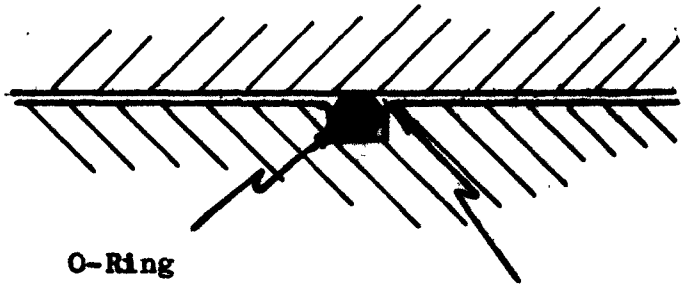
INTRODUCTION

It has been periodically brought to the attention of various Air Force and Industry Agencies that a deficiency exists in the feedback and exchange of missile design information. Several attempts have been made to establish a system which would permit an exchange of deficiency information on a timely basis. However, due to the fast changing technological concepts and the large number of companies involved in missile hardware and system development, the continuing solution to this problem is extremely difficult. This is a consideration to increase the efficiency of exchanging design information. These briefs were compiled by the Missile Safety Division for general use of interested agencies. The design briefs are not in detail, but summarize some of the failure causes which continually jeopardize our missile systems. Comments to the usefulness of this type of a document and suggested improvements are solicited. Reply to the Directorate of Aerospace Safety (AFIAS-M), Norton AFB, Calif.

SUBJECT O-Ring Installation Design

DISCUSSION Numerous seal failures in missile liquid systems have occurred as the result of cut O-rings. The shocking facts are that the majority of the cuts were sustained when the O-rings were rolled over sharp corners during installation. Some of these seal failures have caused extreme safety hazards and loss of expensive equipment.

COMMENT Designers should insure no sharp corners are permitted around the O-ring groove as illustrated in the sketch



SUBJECT Welded Valves and Warped Seats

DISCUSSION During the early construction of ballistic missile sites a serious problem was incorporated which was not detected until subsystem checkouts were performed. Time and again valves had to be replaced because they would not open or close properly. At first this was believed to be a deficiency of the valve. However, further investigation revealed that the valve seats were being warped during welding installation. The valve seats were very close to the weld bead and insufficient cooling was obtained to keep the seats from warping. This resulted in expensive replacements and adversely affected construction schedules. The fact that installed valves of this design were not repairable also contributed to the problem.

COMMENT Designers should be very careful when specifying welded type valves for use in piping systems. Many times the difficulties of installation will outweigh the advantages of the particular valve. When welded valves are specified, caution notes concerning installation instructions may not only save the need of replacement but keep many from passing unfair judgment on the valve manufacturer. If you are a valve designer be sure to consider the repairability of your designed hardware.

SUBJECT High Pressure Flex Hose Connector Material Selection

DISCUSSION An accident which occurred at one of the early missile sites highlighted the need for closer evaluation in the selection of materials used for high pressure hose connectors. In addition to the material deficiency, the investigators of this accident strongly suspected that the designer had failed to calculate all the possible stresses involved. It was believed that an assumption had been made that tensile stresses were the limiting factor when in reality, with the materials used, hoop stresses were the more critical. The metallurgical examination of the fractured connector revealed that an excessive amount of free sulfur was present in the grain boundaries and resulted in a weakened connector. The sulfur had been added to facilitate easier and faster machining during production. The type of fracture was definitely caused by hoop stress exceeding the strength of the material.

COMMENT When selecting material designers should be sure that a complete and thorough evaluation is made of all parameters including production processes and various types of stresses involved. With the decreased safety factors and close tolerances of modern missiles don't take anything for granted if it can possibly be proved by calculations.

SUBJECT Valve Seat Surface Finish

DISCUSSION Recent reports have been received of hydraulic bleed valves leaking under any pressure within various missile systems. The resultant tear-down and failure evaluation concluded that the surface finish on the metal seats was not smooth enough to prevent leakage of the viscous fluids used.

COMMENT When designing metal valve seats or other metal sealing surfaces specify the degree of finish required to assure satisfactory performance.

SUBJECT Improper and Impractical Reliability Specifications

DISCUSSION Too often design engineers generate confusion by specifying a reliability of an item without specifying an associated confidence level. A reliability figure has very little meaning unless it is related to a confidence level. Also, design engineers are sometimes prone to specify a high reliability at a high confidence level without knowledge of the time, effort and expense required to certify the figures. For example, to demonstrate a 0.999 reliability at a 95 per cent confidence level, the item in question must undergo 3024 consecutive tests without a single failure. The following is an illustrative table:

Reliability at a 95% Confidence Level	No. of "No Failure" Tests
0.900	29
0.930	42
0.950	59
0.970	99
0.990	299
0.997	1001
0.998	1500
0.999	3024

COMMENTS High reliabilities at high confidence levels may sometimes be more economically and conveniently achieved by use of duplicate, parallel or redundant components. The design engineer should have a working knowledge of statistical theory. When questions arise he should consult a statistician.

SUBJECT Qualification of Facilities Propellant Loading Valves

DISCUSSION Valves were specified for the propellant loading system without a requirement for operational qualification testing, including individual component suitability. This resulted in cryogenic valves being installed which contained neoprene gaskets rather than teflon. Valves were also used which allowed extrusion of stem packing into the propellant system, thus degrading system contamination levels. The design philosophy had been to use off-the-shelf items based on the assumption that valves would not cause any problems. The results were complete retrofit of many valves, considerable increase in costs, and serious delays in attaining operational use of the facility.

COMMENT Designers should insist that all components in a missile propellant loading system which may degrade the quality of the system be qualified prior to installation in the system. Qualification will increase the system cost but will insure timely acceptance of the installed system.

SUBJECT Incorporate access and cleaning requirements into tank design.

DISCUSSION Several facility propellant storage vessels were designed with enclosed areas which provided sources of considerable contamination. The carbon steel pressurization header was permanently installed with no access for cleaning. Also, tanks were built with internal stiffening rings with intermittent weld beads and openings between butt welds that could not be cleaned to cleanliness levels of missile propellant systems. Improper design greatly increased the cleaning costs of these vessels.

COMMENT Designers should eliminate pockets and traps in propellant vessels that will prevent removal of manufacturing contamination. Accessibility for cleaning operations should be given prime consideration in the internal areas of vessels which must meet propellant cleanliness requirements.

SUBJECT Shut-off Valves for Gas Storage Systems

DISCUSSION A problem of considerable economic proportions was encountered at some of the missile sites which involved the storage of gaseous nitrogen. The storage facility was constructed of numerous individual pressure bottles connected to a common outlet header. This was a fine arrangement considering the volume of gas stored and the pressure involved, except for one thing. There were no individual shut-off valves provided for each bottle. If a leak occurred anyplace in the system all the GN_2 was lost. This resulted in the loss of considerable GN_2 on several occasions and at times created a safety problem due to the lack of oxygen in the surrounding area.

COMMENT When designing a storage system consisting of individual containers connected to a common outlet header provide cutoff valves which will permit isolation of the individual containers.

SUBJECT High Pressure Piping/Tubing Tie Downs

DISCUSSION Several serious accidents have occurred in the past few years as the result of inadequate tie downs for high pressure piping and/or tubing. In these cases the original break and initial release of pressure was not what caused the damage. However, the flailing of the loose pipe or tubing literally beat and cut everything within reach. In one case the action was so violent that large holes were torn in an adjacent control trailer where personnel were located and seriously jeopardized their lives

COMMENT The required spacing of supports for pressure systems are covered in Air Force Technical Order 00-25-223, titled Integrated Pressure Systems and Components. Two tables which are included in the TO are:

Tube OD	Type	Max Working Pressure (PSI	Max Spacing Supports (Feet)
1/4 - 9/16	Gas	6,000-10,000	4
1/4 - 9/16	Gas	Above 10,000	3
1/4 - 9/16	Hydr	6,000-30,000	4

Spacing of Superpressure Tubing Supports

Nominal Pipe Size (Inches)	Maximum Span (Feet @ 100 F) Stainless and Carbon Steel	Aluminum Alloys	Copper
1	8	8	5
1½	9	9	6
2	10	10	6
2½	12	11	7
3	13	12	8
3½	14	13	8
4	15	14	9
5	16	15	10
6	18	16	10
8	19	17	11
10	22	18	13
12	23	20	14

Maximum Recommended Support Spacing for Standard Weight Pipe (Filled with Fluid at 62.4 pounds per Cubic Foot)

SUBJECT Reversible Valves

DISCUSSION A serious problem is created when a valve is designed so that it may be installed backward. A check valve installed backwards will allow fluid to pass in the opposite desired direction and/or many times create an extremely dangerous condition by allowing excessive pressure buildups. A flow control valve installed in reverse will not function properly and may give a dangerous erroneous reading. One may think it is stupid to make such a mistake as installing a valve backward, but it has happened many times in our missile systems.

COMMENT When designing piping systems be sure to select those valves which have different inlet and outlet configurations. If this is impossible, select ones which have the inlet and outlet ports clearly marked.

SUBJECT Incorporation of Fail Safe Design

DISCUSSION The need for missile system designers to apply a basic "fail safe" philosophy has been evident throughout missile installations. For example, a facility work platform for transferring equipment into the silo was designed to be folded upward and latched when a spring catch entered a slot in the work platform. Any vibration caused the catch to loosen and the platform fell to the down position. When this happened during an exercise the platform was torn loose and fell into the silo causing considerable damage. Had the platform been folded downward in the stowed position the platform would not fall during operations. There are similar mechanical and electrical applications throughout the system where "fail safe" design is applicable.

COMMENT Designers should evaluate their design approach to be sure that the fail safe principal is used in missile systems wherever possible. This will help eliminate problems caused by vibration and incidents where the systems fail to operate in the prescribed manner.

SUBJECT Shut-off Valves to Isolate Long Hydraulic Loops

DISCUSSION It sometimes becomes necessary to isolate one section of a hydraulic system to permit disassembly for maintenance purposes or to stop a leak. Unless the system is suitably equipped with shut-off valves, it may be necessary to drain a large section of the system instead of a small portion.

COMMENT It is recommended that hydraulic systems be equipped with shut-off valves at points which will permit isolation of portions of the system. Such valves should be located at branch points. Further, they should be located wherever possible, at points of access where they can be reached easily in the event of an emergency.

SUBJECT Pressure Bleed Valves for High Pressure Lines

DISCUSSION High pressure systems have sometimes been opened when residual pressures still remained, causing injury to personnel. These accidents have occurred because the lines were not equipped with bleed or test connections. In other cases, the poor location of bleed valves has almost resulted in accidents when discharges through them have hit face shields or other equipment of the operating personnel.

COMMENT It is recommended that each high pressure line which may be disassembled at some time after use be provided with a bleed valve to test its condition. These bleed valves should not be oriented so that any discharge will hit any part of the anatomy of personnel operating them. They especially should avoid being horizontal at eye level.

SUBJECT Damage caused by not Isolating Components from Vibration.

DISCUSSION Damage may result to missile components due to the fact that they have not been isolated from vibration. This vibration may be caused by the exhaust gases passing through the exhaust nozzle of a missile engine. Vibration may weaken metals by fatigue to the point where moderate stresses may cause failure. Vibrations may also cause the loosening of connections.

COMMENT It is recommended that wherever possible critical components be isolated from sources of damaging vibration. Entire assemblies may be equipped with rubber or spring shock mounts. Piping may utilize flexible connections.

SUBJECT Revolving Portal Entrance Doors

DISCUSSION Revolving portal doors have been located directly at the bottom of stairways thus creating a safety hazard. An individual falling down the stairs may fall into the revolving doors and sustain serious physical injury. In one instance a fatality has occurred due to this design fault.

COMMENT Future design of similar facilities should recognize the inherent hazards when any type of revolving doors are placed directly in line with connecting staircases. With this in mind, necessary design changes should be made to eliminate this hazard.

SUBJECT Hydrocarbon Fluid Drip Pans in LOX Areas

DISCUSSION Several instances have been noted where diesel generator engines and similar pieces of equipment have no protection to prevent hydrocarbon fuels from leaking to lower launcher levels. Such leaks can very easily come in contact with LOX fuel equipment and cause an extremely hazardous condition.

COMMENT Drip pans and/or solid floors with a curbing should be placed under equipment using hydrocarbon fuels. This method would contain possible leaking fuels and thus prevent them from contaminating other equipment areas.

SUBJECT Storage of Work Platform Safety Rails

DISCUSSION There have been instances where missile enclosure safety rails have been left in place when work platforms have been raised. This oversight can cause damage to the rails, platforms, missile enclosure, missile, and AGE.

COMMENT Facility Designers should specify a numbering system and method of storing these safety rails when not in use.

SUBJECT Calibration of System Components

DISCUSSION The periodic calibration of gages, pressure switches, regulators, relief valves, etc., is of utmost importance to insure the safe and proper functioning of missile systems. A gage out of tolerance will prompt decisions which may degrade the system or result in an accident. If critical pressure switches (transducers), regulators, relief valves, etc., go out of limits it is easy to visualize the catastrophic consequences. These critical items must be calibrated periodically in accordance with the manufacturers recommendations. One of the basic problems associated with calibration is the time required for removal and replacement of the equipment to be calibrated. This factor is often overlooked in the piping systems design stage.

COMMENT There would be less opposition to the calibration programs if system design recognized the need for shut off valves, quick disconnects and bleed valves to isolate all items which must be calibrated. This would facilitate quick removal and replacement or allow for in-place calibration.

SUBJECT Missile Protection during Lift Operation

DISCUSSION The missile launcher system was designed without providing an interlock which would prevent raising the missile when the silo door was in the closed position. Inadvertent operation of the missile lift would result in the missile being crushed against the silo door. In complex missile systems interlocks are necessary in any operation which may wreck a missile if some preceding operation has not been completed.

COMMENT The missile launch system was redesigned to include an interlock which would prevent operation of the lift when the silo door is closed. Other interlocks were installed in systems where a malfunction would result in damage to the missile or injury to personnel. This insures safe operation of the missile system.

SUBJECT Exposed Electrical Terminals

DISCUSSION An air-to-ground missile was experiencing recurring electrical malfunctions. The trouble was eventually traced to the presence of moisture on one of the main electrical terminal panels. During inclement weather, or during climb to or descent from altitude, moisture was either draining or condensing on the exposed and unprotected terminal panel, causing intermittent shorts.

COMMENT The terminal panel and its associated electrical contacts were painted over with a waterproof, non-conducting material.

SUBJECT RF Protection for EEDs

DISCUSSION There has been much concern about the possibility of igniting electro-explosive devices by incident radio frequency (RF) energy. Theoretically, a worse case is approximated by an electrical lead to an EED acting as a short-stub antenna (say 1/20th the wave length of the RF field). Under these conditions the power transferred to the EED bridgewire is about:

$$P_L = \frac{0.24 P_d \lambda^2 R_L}{(R_L + 1.0)^2}$$

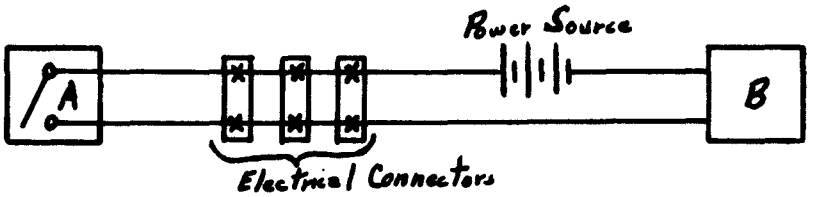
where P_L is power delivered to the bridgewire, P_d is power density of the RF field, λ is the wave length of the RF field, and R_L is the bridgewire ohmic resistance.

COMMENT 1. Design criteria for the EED should require the largest possible no-fire current that is compatible with the EED application.

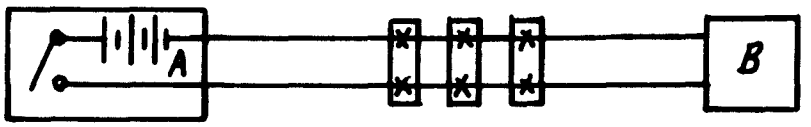
2. The RF hazard depends on the leads of the EED acting as an antenna. The hazard can therefore be reduced by any technique which destroys or diminishes the EED antenna characteristics (i.e., shielding, twisting leads).

SUBJECT Protection against Short-Circuits

DISCUSSION In one particular missile the premature or accidental activation of component "B" would have resulted in a major accident. The firing circuit for component "B" was designed as indicated in the schematic below. It should be noted that a short-circuit in any one of the several electrical connectors (a favorite location for short-circuits) would energize component "B".



COMMENT The power source should be relocated in component "A" so that a short in the cable or its connectors would not be disastrous.



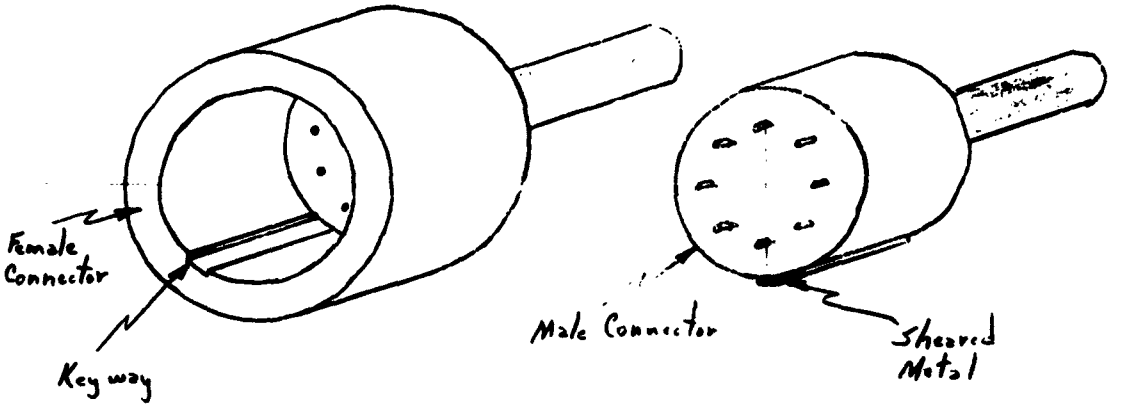
SUBJECT Compromised Reliability, Control & Power Lines

DISCUSSION A missile subsystem was engineered to have an extremely high reliability at a high confidence level. However, in connecting the subsystem into the missile system, control and power lines were routed in cables shared by other subsystems through several electrical plugs connected in series. Also, within the several plugs, firing lines to the subsystems were located on adjacent pins. This configuration of the interfaces caused a reduction in the overall reliability of the subsystem by more than one order of magnitude.

COMMENT Design engineers concerned with a high reliability of a subsystem should also concern themselves with the reliability of interfaces. Insofar as possible separate cable routing should be used, interfaces and electrical connectors should be kept to a minimum, and firing pins within the same connector should not be adjacent.

SUBJECT Electrical Connector Keyway Design

DISCUSSION Not too long ago a man was injured and thrown approximately 10 feet when he attempted to plug in an electrical connector to a 440 volt power source. In examining the burned connector it was determined that mating had been attempted 180 degrees out of proper alignment. How was it possible to mismate an electrical connector designed with a keyway to prevent such things? One look at the key way on the damaged connector and several other good connectors told the story. The keyway was not deep enough and with a little wear the soft metal was sheared from the male ridge making it possible to easily mismate many of the connectors. This deficiency is illustrated in the sketch below:

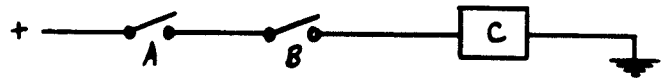


COMMENT

1. Design electrical keyways deeper and/or wider to prevent excessive wear.
2. Specify more than one keyway for each connector.
3. Design noncircular pins and/or place pins in an unsymetrical order.
4. Design a special guide pin or pins which would prevent misalignment.
5. Manufacture connectors from more durable metal which will resist wear.

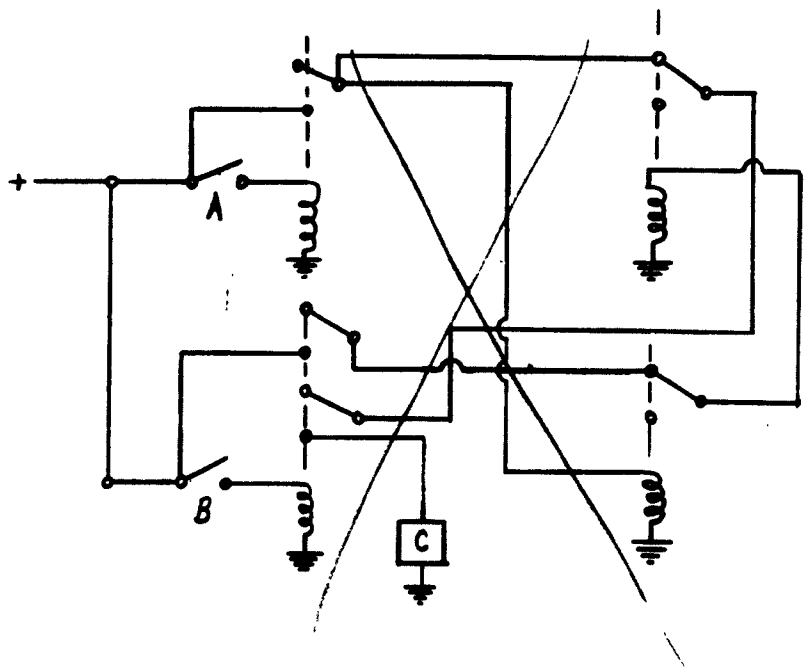
SUBJECT Sequential Multi-Switch Operation for Critical Circuits

DISCUSSION Many critical circuits are designed not to actuate until and unless several switches are first closed. Consequently a deliberate, conscious action is required for circuit activation and the possibility of accidental activation is thereby reduced.



The possibility can be further reduced by installation of a simple logic circuit requiring sequential operation of the switches.

COMMENT The schematic below represents a typical logic circuit which requires the sequential closure of first switch "A" and the switch "B" before voltage can be applied to component "C".

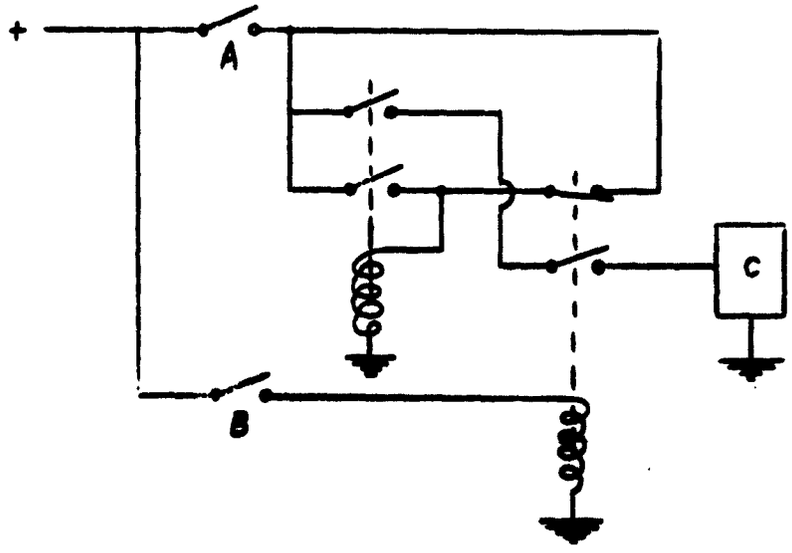


SUBJECT Sequential Multi-Switch Operation for Critical Circuits

DISCUSSION Many critical circuits are designed not to actuate until and unless several switches are first closed. Consequently a deliberate, conscious action is required for circuit activation and the possibility of accidental activation is thereby reduced.

The possibility can be further reduced by installation of a simple logic circuit requiring sequential operation of the switches.

COMMENT The schematic below represents a typical logic circuit which requires the sequential closure of first switch "A" and the switch "B" before voltage can be applied to component "C".



CORRECTED COPY

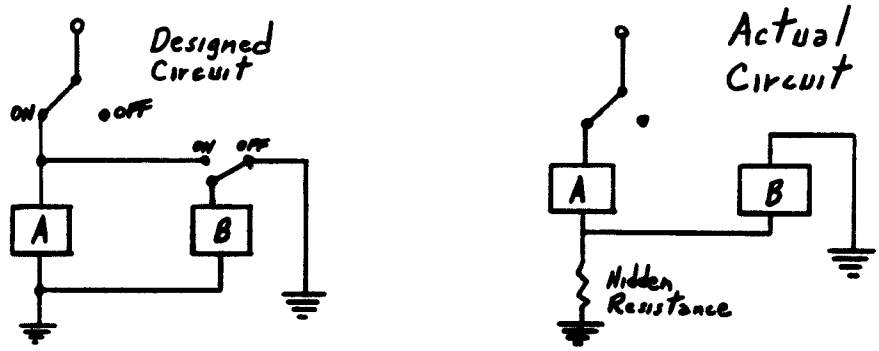
SUBJECT Shock Hazard at Connectors when Large Filter Capacitors Retain Charge.

DISCUSSION Capacitors are usually provided in electronic equipment to suppress or filter out unwanted radio noise. These relatively large filter capacitors in the network of the electronic circuitry will retain their charge even when the power source is de-energized. Furthermore, this voltage remains for long periods of time. The voltage across the plates of the capacitor usually approximates the source voltage. When source voltage is high voltage A/C, inadvertently touching a connector under the above conditions constitutes a serious electrical shock hazard. It should be noted that 60-cycle voltages even as low as 35 volts have been known to kill.

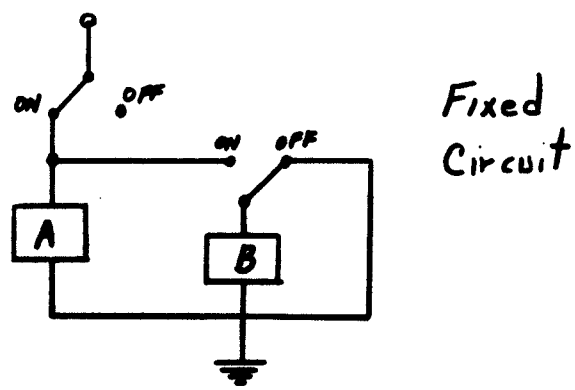
COMMENT Design should provide for bleeder resistors to discharge capacitors when the equipment is de-energized.

SUBJECT Current Leakage through Multiple Ground Contacts

DISCUSSION When component "A" was activated during flight of a cruise missile, component "B" was inadvertently actuated and the missile was destroyed. Subsequent analysis indicated component "B" had been energized by ground leakage current caused by the existence of a "hidden" or unintentional resistance between the ground contact and the actual ground.



COMMENT A fix was made by use of a common ground.



SUBJECT Dissimilar Metals

DISCUSSION When components are made of dissimilar materials electrolytic action may take place with water acting as a catalyst. Water finds its way into components by either leakage or condensation. This situation is most serious with electrical components such as connectors, junction boxes, etc. The corrosion caused by the electrolytic action can cause shorts and stray voltages with possibly catastrophic consequences.

COMMENT

1. Use similar metals for component construction.
2. When dissimilar metals must be used, be sure adequate insulation is provided to prevent electrolytic action.
3. Encapsulate internal electrical components to seal them from water due to either leakage or condensation.

SUBJECT Electrical Connector Installation with Respect to Moisture

DISCUSSION There have been many reported incidents and accidents whereby electrical circuits have malfunctioned due to moisture within or around the contacts and wires joined within the connector. Upon investigation, it has been determined that one or more of the following three factors were directly responsible for the reported malfunctioning connector:

a. The connector which malfunctioned was not designed to be used in the environment in which it was installed.

b. The connector which failed electrically or mechanically was not properly fabricated from quality materials.

c. The connector malfunctioned because it was improperly handled by careless personnel either in supply channels or during installation.

COMMENT 1. Detailed consideration should be given to each connector chosen to be used in a known environment. Only when it has been proven that a certain connector can withstand the environmental conditions in which it will be placed should it be selected and incorporated into its subsystem.

2. Once a specific electrical connector has been selected for use, the necessary amount of quality control supervision must be exercised to assure that only the design materials have been utilized in its fabrication.

3. All personnel responsible for handling, shipping, or installing electrical connectors must exercise the necessary care when working with these connectors.

SUBJECT Pin to Case Dielectric Strength for EEDs

DISCUSSION The problem of protection against static electricity is the most critical in the field of electro-explosive devices. If a sufficient charge builds up on the case or the pins an arc will occur between the bridgewire circuit and the case and when this arc passes through the pyrotechnic material it will explode. Theoretically a person can store a static charge equivalent to a 500 millimilli farad capacitor charged to a potential of 15,000 volts - quite sufficient to explode most squibs. A shorting plug is absolutely necessary during handling and storage operations as it equalizes the potential between the case and the pins. When installing the device, however, the shorting plug must be removed. The squib is then vulnerable to the human element as well as any static charge inadvertently deposited on the lead wires. Several costly missile incidents have been attributed to such inadvertent electrostatic charges.

COMMENT The obvious solution to this problem is to enclose the bridge wire circuit and the explosive in a material of sufficient dielectric strength to prevent the discharge. Increasing the dielectric strengths of the pyrotechnic material would also be beneficial. Unfortunately the limitations of the total size of some of these devices limits the physical spacing between the bridge wire circuits, the explosive and the outer case. The case itself might be made of a dielectric (plastic) material if it did not have to withstand high pressure, temperatures, etc. The design goal, however, should be to design squibs with the highest practical pin to case breakdown voltage. For small squibs the present state of the art appears to be 1000 volts. The industry should continue their efforts, however, to break the design barrier and build conventional type squibs to withstand pin to case breakdown voltages of up to 25,000 volts.

SUBJECT Location of Signal and Power Wires

DISCUSSION It has been found in several missile and aircraft systems that both signal and AC/DC power wires have been placed within the same missile or aircraft harness or conduits. These cables in many cases join in common connectors whose pins have become shorted and caused electrical malfunctions. These malfunctions have been caused by careless personnel handling, moisture, dielectric breakdown, and/or lack of quality control in manufacture.

COMMENT It is advisable to assure that signal circuits and power circuits are never designed nor fabricated to be placed side by side in the same cable or common connector. These circuits should always run in separate cables or harnesses and never pass through adjacent pins in a common connector. If possible, two separate connectors should be used for routing signal and power circuits.

SUBJECT Solid Rocket Motor Temperature and Moisture Limitations

DISCUSSION Solid grain rocket motors when conditioned to temperatures of -20°F or lower and high humidity have created serious safety hazards. When fired, the motor case has ruptured with extreme violence. This is caused by excessive and rapid pressure rise within the motor at the time of ignition. The phenomena does not occur when the motor temperature is conditioned to 0°F or higher. It is readily seen that a serious problem exists when an aircraft loaded with external solid motor weapons is subjected to very low temperatures and high humidity. A ruptured motor case not only degrades operational capability but can destroy the aircraft and jeopardize the lives of the air crew members.

COMMENT Solid grain propellant formulations should be developed that can be subjected to low temperatures and high humidity without creating a safety hazard when fired. If this is not possible then the safe operating limitations of a motor should be clearly defined to the operational personnel.

SUBJECT Non-LOX Compatible Materials Located in LOX Handling Areas.

DISCUSSION Non-LOX compatible asphalt material was used for paving the LOX transfer areas at missile sites. In addition, non-LOX compatible joint sealer was used in concrete joints and non-LOX compatible material in a GOX vent shaft was suspected as a contributing factor in an explosion and fire which destroyed the operational use of a missile silo. The facilities area is especially subject to the introduction of non-LOX compatible materials. This is due to the manner in which the contractor is able to select the materials applied.

COMMENT The responsible design representatives should personally determine and specify the LOX compatible materials which may be used in the facilities area to assure that no built-in hazards are allowed to develop.

SUBJECT Hydrazine Tank Burst Diaphragm Leaking

DISCUSSION Numerous hydrazine leaks have been reported around hydrazine bottle outlet ports. Investigation and review of manufacturer procedures of burst diaphragm assemblies did not indicate any apparent fabrication deficiency that would result in leaks. However, subsequent investigation revealed that the diaphragm material was not totally compatible with hydrazine.

COMMENT 1. Material improvement project recommended the use of hydrazine compatible materials.

2. Consideration should be given to determine the long term storage compatibility of diaphragm material and hydrazine.

SUBJECT Fuel Expulsion Diaphragm

DISCUSSION Fuel expulsion diaphragms, although a relative simple component, have failed repeatedly for obscure reasons. The expulsion diaphragm is made of rubberized fabric and is used to expel fuel from a tank by the action of pressurized gas on the opposite side of the diaphragm. There is no apparent specific reason or condition that is causing the diaphragms to rupture in service. Examinations of several failed diaphragms indicated failure due to the fabric being stressed beyond strength limits. Extensive tests indicated that fabric strength was adequate. Material compatibility or short service life due to chemical action was investigated and discounted.

COMMENT Extensive rechecking of quality control requirements during the entire process of diaphragm fabrication may indicate deficiencies in techniques. In many past instances a well designed piece of equipment was deficient only because of inadequate fabrication and manufacturing techniques.

SUBJECT Drain Valves in Liquid Systems

DISCUSSION Situations have resulted in missile systems in which residual amounts of liquid have remained in low points of piping systems. This may result in the presence of substantial amounts of toxic or corrosive liquids in lines opened by maintenance personnel. In addition, condensable liquids present in high pressure lines may be accelerated to high speed with the possibility of causing damage by a water hammer effect.

COMMENT It is recommended that drain valves be provided at the low points of each liquid system. Lines should be sloped to permit any accumulations of liquid to be directed to the points where the drain valves are located. Discharges from the drain valves should be conducted to suitable disposal facilities.

SUBJECT Chemical Vapor Detection System

DISCUSSION Present Air Force liquid propellant vapor detection systems are complex instruments and expensive. The detection instruments require considerable maintenance to maintain an acceptable degree of reliability. The systems are vapor point sensors which detect contaminated atmosphere only at a point source pick-up. The detection will indicate a hazardous atmosphere after a leak has occurred. The detectors will not sense a condition that will preclude the build up of a hazardous atmosphere, in other words a leak detector.

COMMENT It is recommended that emphasis be placed on the prevention of and detection of initial leaks, rather than the sampling of atmosphere contaminated as the result of a leak.

SUBJECT Contamination by Internal Failure of Propellant Loading Systems

DISCUSSION In several cases the fuel or oxidizer has been contaminated with debris when filters or valves have failed during propellant loading. This debris can cause valve or turbo pump failure during missile launch or static firing and jeopardize safety of both personnel and equipment.

COMMENT A locking device should be designed for each critical component in the propellant loading system to preclude failed parts from flowing downstream and causing further damage.

SUBJECT Missile Propellant Tank Loading and Liquid Level Control Instrumentation

DISCUSSION

1. Present Air Force missile propellant tankage when fueled are quantitatively measured and monitored by one of the following methods:

a. Weighing the propellants prior to fueling the missile tanks.

b. Flow control instruments which indicates the amount of propellant transferred into missile tanks.

c. Liquid level instrumentation which determines the quantity of propellants in a tank.

2. Incidents have repeatedly occurred in which missile propellant tanks were overfilled or underfilled. In one instance, a missile was destroyed due to fuel overfill. Fueling a missile with precise quantity of propellants is an extremely critical operational function. It is obvious that incorrect amounts of propellant may compromise missile mission capability.

COMMENT When specifying a method for determining propellant quantity, considerations should be given to all aspects of a weapon system. Be sure that methods and design specified will perform within propellant flow and quantity tolerances.

SUBJECT Reverse Flow Filters

DISCUSSION There has been a general trend in recent months to specify a reverse flow capability for propellant transfer filters. This is alarming and destroys basic filtration principles. When the direction of fluid flow is reversed the trapped contaminants are released and again contaminate the propellants. With the use of or the vaporization of the propellants the contaminate level increases in the transfer system upstream of the filters. This process will definitely increase the wear on valves and other system components with possible catastrophic failures.

COMMENT If reverse flow capabilities are needed in a fluid transfer system then the design should call for parallel or bypass arrangement of filters. The design should assure that fluid flows in only one direction through any filters.

SUBJECT Separate Routing of Fuel and Oxidizer Lines

DISCUSSION Fuel and oxidizer lines were routed in the same general area of the facility. Whenever a line leaked there was a strong possibility of the fuel and oxidizer mixing to form a LOX gel which is very impact sensitive.

COMMENT Fuel and oxidizer lines should be routed on opposite sides of the facility. In addition, care should be taken that hydrocarbon fluids will not be routed over or under LOX lines where spills can result in a combination of the propellants. The proper layout of propellant systems will greatly reduce the possibility of propellants combining during spills and will enhance the safety of the facility.

DISTRIBUTION LIST

HQ USAF

AFIIS	5
AFRDC	10
AFSDC	20

SAC

SAC Offutt AFB Nebr	10

TAC

TAC Langley AFB Va	10

AFLC

AFLC Wright-Patterson AFB Ohio	25
SBAMA Norton AFB Calif	5
OOAMA Hill AFB Utah	5
MAAMA Olmsted AFB Pa	5
OCAMA Tinker AFB Okla	5
MOAMA Brookley AFB Ala	5
WRAMA Robins AFB Ga	5
SAAMA Kelly AFB Tex	5

AFSC

AFSC Andrews AFB Wash 25 DC SCIZ (LtCol L.E.Stone, Chief, Safety Div)	25
BSD (Safety Office) Norton AFB Calif	20
SSD (Safety Office) AF Unit Post Office Los Angeles 45 Calif	20
ASD (Safety Office) Wright-Patterson AFB Ohio	20
ESD (Safety Office) L.G.Hanscom Fld Bedford Mass	20

ATC

ATC Randolph AFB Tex	10

ADC

ADC Ent AFB Colo	10

CONTRACT MANAGEMENT REGIONS

CCMR Wright-Patterson AFB Ohio	100
ECMR Olmsted AFB Pa	100
WCMR Mira Loma AFS Mira Loma Calif	100

AFPRO

AFPRO Aerojet-General Corp P O Box 2048 Sacramento 10 Calif	20
AFPRO The Boeing Co P O Box 3707 Seattle 24 Wash	20
AFPRO Douglas Acft Co Inc 3000 Ocean Park Blvd Santa Monica Calif	20
AFPRO Douglas Acft Co Inc 2000 N Memorial Dr Tulsa 15, Okla	20
AFPRO Gen Dynamics/Ft Worth P O Box 371 Ft Worth Tex	20
AFPRO Gen Dynamics/Astronautics P O Box 1128 San Diego 12 Calif	20
AFPRO GE Co P O Box 91 Lockland Br Cincinnati 15 Ohio	20
AFPRO GE Co Electronics Park Syracuse NY	20
AFPRO Hughes Acft Co & Hughes Tool Co - Acft Div Culver City Calif	20
AFPRO Lockheed Acft Corp P O Box 551 Burbank Calif	20
AFPRO Lockheed Msl & Space Co P O Box 504 Sunnyvale Calif	20
AFPRO Lockheed Acft Corp Marietta Ga	20
AFPRO The Martin Co P O Box 179 Denver Colo	20
AFPRO N American-Autonetics Div Anaheim Calif	20
AFPRO N American Los Angeles Div Los Angeles Intl Aprt Los Angeles 45 Calif	20
AFPRO N American Rocketdyne Div Canoga Park Calif	20
AFPRO Northrop Corp Hawthorne Calif	20

AFPRO Republic Avn Corp Farmingdale Long Island N Y	20
AFPRO Sperry Gyroscope Co Great Neck Long Island N Y	20
Wichita AFPRO AF Plant No. 13 3801 S Oliver Wichita Kans	20