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NON-NUCLEAR SAFETY  
CONSIDERATIONS FOR  
THE R-I-F-T PROGRAM

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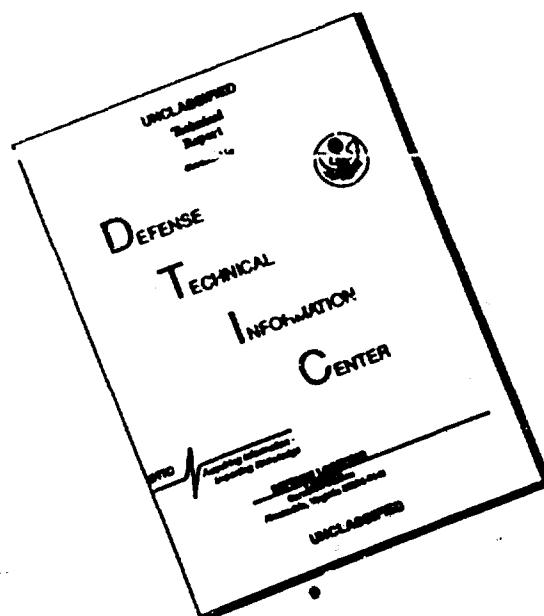
GENERAL DYNAMICS  
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A2136-1 (REV. 6-61)

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GENERAL DYNAMICS  
ASTRONAUTICS

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1/ PURPOSE

The purpose of this document is to define the basic non-nuclear safety program for the R-I-F-T project.

## 2/ INTRODUCTION

A comprehensive and effective safety program will be mandatory during the design and operational phases of the R-I-F-T program. There is a direct correlation between a safe operation and efficiency. The monetary and psychological value of such a plan of action will more than compensate for its cost and effort. The program will reflect reduced medical costs, compensation payments, insurance premiums, retraining costs, idle time costs, etc. In addition to history of public "good will" will be developed which is vital to all agencies involved.

Safety at General Dynamics/Astronautics is the direct responsibility of supervision. The formal safety policy is outlined in our "Standard Practices" approved by the President of the division Mr. J. R. Dempsey. Specific safety rules and regulations are written and/or approved by the Chief Safety Engineer. An effective safety program is however very much dependent upon team work between the employees and supervisors. The Astronautics organization has generated and maintained this support which is confirmed by our fine safety record. Since the inception of our present organization in 1956 we have finished third once, second twice and first for the calendar year 1960 in the Aerospace Industries section of the National Safety Council Contest. In addition we have received five separate awards of Honor from the Council for having worked over 5,000,000 manhours without a disabling injury.

The safety program for the R-I-F-T project will involve three facilities:

Manufacturing Plant

Nevada Test Site

Atlantic Missile Range

Since the safety problems and responsibilities at these three facilities differ widely and due to their geographic dispersion, it will be necessary to have a safety section at each facility. Figure 1 shows the lines of responsibilities for the R-I-F-T safety program within Astronautics.

The safety program will initially take shape at the manufacturing facility. The initial task of the organization will be to review the design of the vehicle hardware, the vehicle system in general, the manufacturing and test facilities and the operational test plans. This will enable a maximum influence to be brought to bare with respect to safety. Considerable knowledge and experience will be gained during this period by the safety personnel which will be of substantial benefit during the operational testing phase.

Astronautics will be responsible for all phases of the safety at the Nevada Test Site. Therefore, during the design and manufacturing phases the problems of static testing will constantly be studied so that an optimum test program will be realized.

During the test flight operations the Astronautics safety personnel at AMR will work with the Range Contractor (PAA) and other applicable agencies in co-ordinating and implementing procedures to maximize safety. Close liaison will be maintained with the Pad Safety Supervisor who has the final authority on matters of safety within the launch complex, launch area (land) and is in charge of the missile launch impact convey.

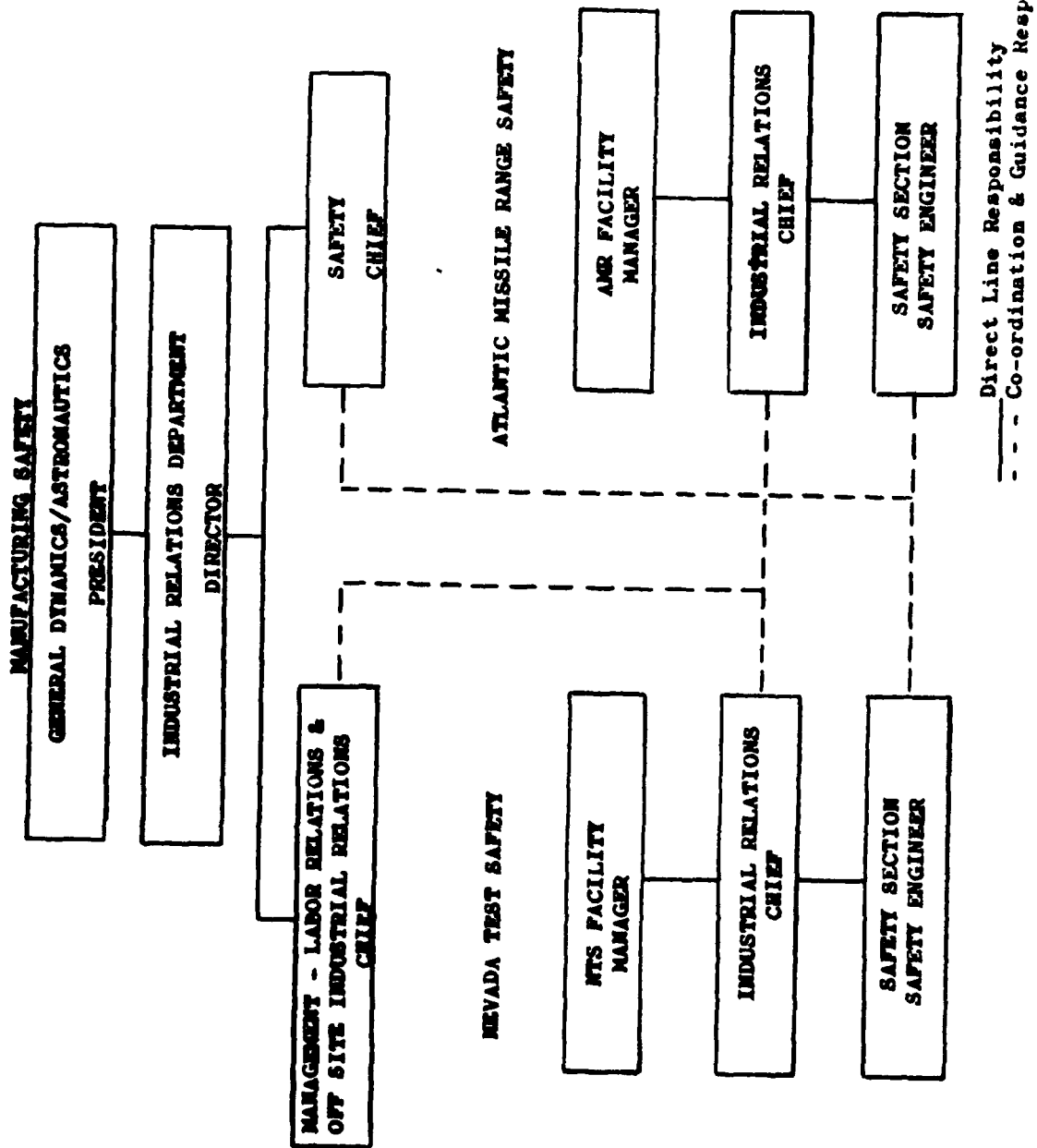


Figure 1



### 3/ DUTIES AND RESPONSIBILITIES

It is the policy of General Dynamics/Astronautics that all practical measures shall be taken to insure the safety of the employees. Supervisory personnel shall be held responsible for the actions of their employees, the maintenance of safe working conditions in their respective areas, seeing that all injuries regardless of severity are reported to the Medical Section immediately, and for strict enforcement of all Safety Rules and Regulations authorized by Operating Division Management.<sup>1</sup>

The Industrial Relations Department will be responsible for implementing and supporting the above policy. In accomplishing this task the Safety

Engineer will:

- a. Act in an advisory capacity to management on all matters pertaining to safety.
- b. Maintain close liaison with other departments such as engineering, personnel, Medical, Education, etc. on matters pertaining to safety.
- c. Maintain appropriate records.
- d. Make certain that federal, state, and local laws and/or ordinances bearing on industrial safety are complied with.
- e. Maintain outside professional contacts, such as with the AEC, Labor Dept., Insurance Co., etc, on matters pertaining to safety.

1. Standard Practice, No. 2-19, dated 1/12/61.

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- f. Initiate activities that will stimulate and maintain the interest of employees in safety.
- g. Establish and publish Safety Rules and Regulations.
- h. Organize Safety Committees, meetings and programs.
- i. Conduct surveillance of all areas to eliminate unsafe conditions and insure that supervisors and employees are complying with safety policies.
- j. Investigate accidents to determine unsafe practices, and workman's Compensation claims.
- k. Provide assistance to the Accident Investigation Board on missile tests accidents.

#### 4/ IMPLEMENTATION

In order to stimulate safety consciousness and develop fully the understanding that all employees have individual roles in accident prevention and to promulgate safety information the following activities will be instituted:

"Chain-Reaction" Safety meetings

Safety Support Notations

Safety Contest

Education support activities

a. "Chain-Reaction" Safety meetings

- (1) Executive Committee Meeting - The chairman will be the Director of Industrial Relations or the Off-Site Facility Manager with membership limited to Department Heads and above. The purpose of the committee will be to generate concern for safety at the top organizational level and start the "communication network" that is designed to reach every employee.
- (2) Department, Safety Meeting - The chairman will be the Function head of the department and attended by all the supervisors under the chairman's control. The purpose of the meeting will be to establish responsibility of each supervisor for conducting follow-up safety meeting with their employees.
- (3) Supervisor - Employee Safety Meeting - The meeting will be

chaired by the supervisor and attended by all employees under the chairman. The purpose of the meeting is to establish the personal responsibility of each employee for "working safety".

- (4) **Workman's Safety Committee Meeting** - The meeting will be chaired by the supervisor and its members will be non-supervisory employees. The membership will rotate between the employees with a term of four months. The purpose of the committee is to create an "on-the-job" group intent on seeing safe working conditions. This will be the "feedback" point in the chain of safety meetings.

**b. Safety Support Notations**

The safety support notations are forms used by the safety engineer to inform supervisors and employees of unsafe working conditions noted during a safety inspection. Follow-up action must be taken on all Safety Support Notations given. A sample of the form is shown in figure 2.

**c. Safety Contest**

Contest will be used to stimulate interest and action in regards to safety.

**d. Education Support Activities**

The purpose of the educational program will be to generate the desired knowledge and attitude towards safety.

**SAFETY SUPPORT NOTATION**

**Dept.** \_\_\_\_\_ **Date** \_\_\_\_\_ **Time** \_\_\_\_\_

**Employee:** \_\_\_\_\_ **Clock**  
**No.** \_\_\_\_\_

**Safety Item:** \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**Supervisor:** \_\_\_\_\_

**Issued by:** \_\_\_\_\_

**Safety Engineer**

**Is employee aware of this Safety Regulation?**

**Figure 2**

5/ RECORDS AND STATISTICS

Properly kept records and well presented statistics will provide supervision with the data necessary in formulating safety policy. The effectiveness of the safety program can be judged on the basis of the collected data. Such information can also be used to create interest in safety.

The following Records will be maintained:

1. Personal Injury Notice (Figure 3). completed by the Medical Department on all first-aid treatments.
2. Supervisor's Report of Accident Investigation (Figure 4) - completed by the supervisor on all injured employees.
3. Employer's Report of Industrial Injury (Figure 5) - completed by the safety Engineer investigating the serious medical cases.
4. Serious Medical cases Monthly Summary (Not shown) - assembled by the Safety Engineer giving the names of the injured employees, Department, shift, date of injuries and nature of the injuries.
5. Safety News Letter (Not shown) - Written by the Safety Engineer giving safety statistics and other information related to safety.
6. Department Safety Statistics (Not shown) - Completed by the safety office giving all injuries vs total man-hours worked and other pertinent data.
7. Division Accident Report (Not shown) - A monthly report completed by the Safety Office giving the applicable information for the month and year to date
8. Serious Medical Case Chart (Figure 6) - Maintained by the

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**safety office giving the number of foot, hand, eye and back cases plus frequency and severity.**

- 9. Report of Work Injuries (Not shown) - completed by the Safety office quarterly for the U. S. Department of Labor.**
- 10. National Safety Council Contest Report - Completed by the Safety office and submitted monthly.**
- 11. Good Housekeeping Sheet (Figure 7) - completed by the inspecting safety Engineer.**
- 12. Housekeeping Report (Not shown) - monthly summary sheet completed by the Safety Office.**

# SERIOUS MEDICAL CASES 1957-1958

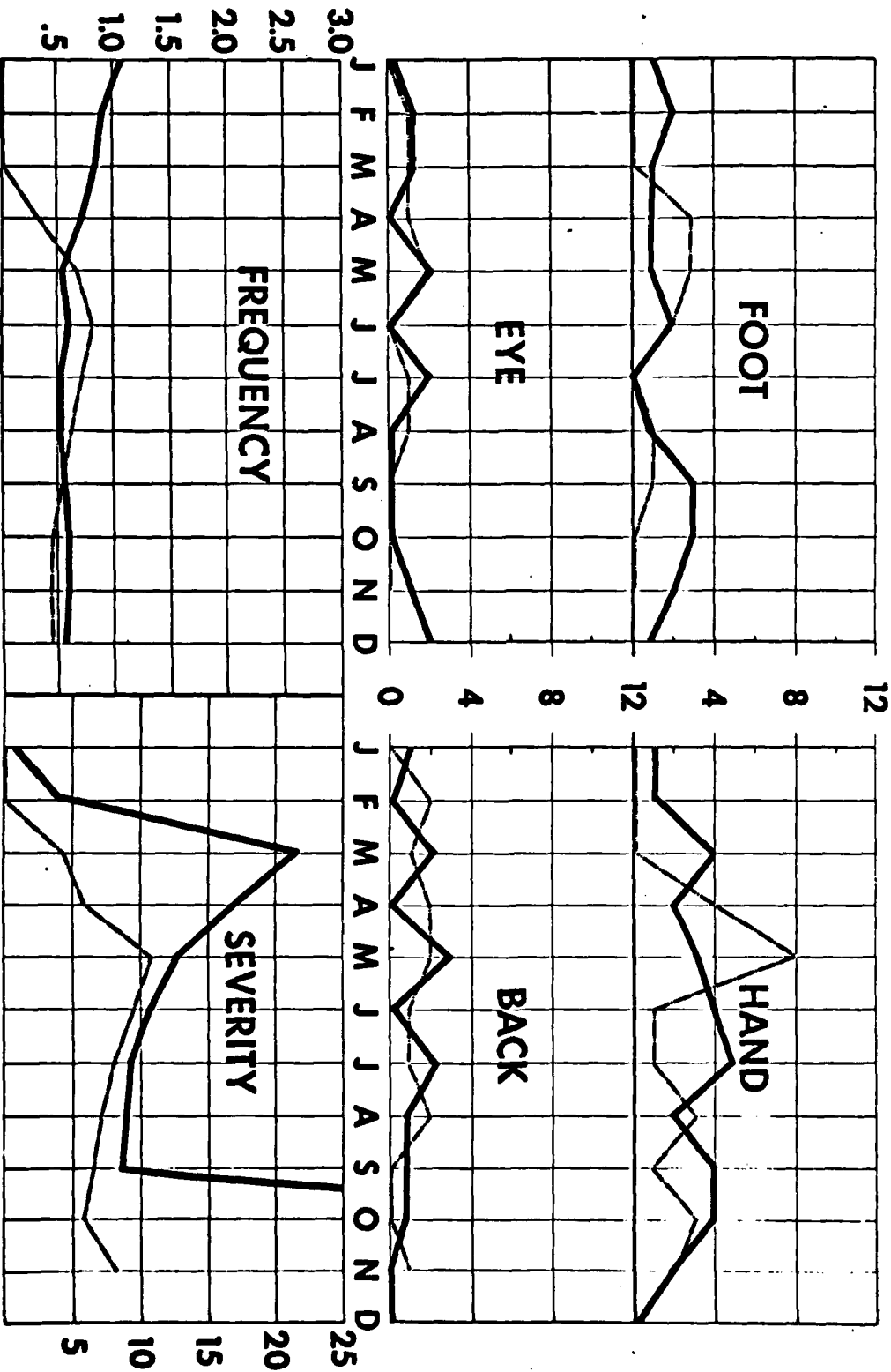


Figure 6



# GOOD HOUSEKEEPING CHECK SHEET

MONTH OF \_\_\_\_\_

DATE \_\_\_\_\_

DEPARTMENT NAME \_\_\_\_\_

DEPT. NO. \_\_\_\_\_

## CLEANLINESS & ORDERLINESS (1 POINT)

| VIOLATION | SUBJECT         | LOCATION | VIOLATION | SUBJECT            | LOCATION |
|-----------|-----------------|----------|-----------|--------------------|----------|
|           | CLOTHING        |          |           | SUPPLIES           |          |
|           | LUNCH BOXES     |          |           | STORAGE UNTIDY     |          |
|           | TOILET AREAS    |          |           | AISLES             |          |
|           | NEWSPAPERS      |          |           | FLOORS             |          |
|           | RUBBISH         |          |           | MAKE SHIFT STORAGE |          |
|           | TOOLS           |          |           | ACCUMULATION AREAS |          |
|           | STOCK           |          |           | MIXED SALVAGE      |          |
|           | DISCARDED BUTTS |          |           | DUSTY EQUIPMENT    |          |
|           | DESKS UNTIDY    |          |           |                    |          |

## FIRE (10 POINTS)

| VIOLATION | SUBJECT                  | LOCATION | VIOLATION | SUBJECT                | LOCATION |
|-----------|--------------------------|----------|-----------|------------------------|----------|
|           | FIRE EXTINGUISHER: INOP. |          |           | FLOOR DRAINS           |          |
|           | SPRINKLER HOS. CLEAR     |          |           | RUBBISH                |          |
|           | VOLATILE LIQUIDS         |          |           | FLOOR CONDITIONS       |          |
|           | FIRE PROT. COVERAGE      |          |           | BUTTS NOT EXTINGUISHED |          |

## SAFETY (10 POINTS)

| VIOLATION | SUBJECT            | LOCATION | VIOLATION | SUBJECT                | LOCATION |
|-----------|--------------------|----------|-----------|------------------------|----------|
|           | GUARDS             |          |           | UNSAFE EQUIPMENT       |          |
|           | STANDS             |          |           | UNSAFE ACTS            |          |
|           | LADDERS            |          |           | SAFETY CLOTH. & EQUIP. |          |
|           | EYE PROTECTION     |          |           | OVERLOADING            |          |
|           | HANDLING           |          |           | STORING                |          |
|           | UNIDENT. VOLATILES |          |           | HORSEPLAY              |          |

REMARKS:

VIOLATIONS (POINTS)

CLEANLINESS \_\_\_\_\_  
 FIRE \_\_\_\_\_  
 SAFETY \_\_\_\_\_  
 TOTAL POINTS \_\_\_\_\_

ED BY: (SIGNATURE)

VERIFIED BY: (SIGNATURE)

INSPECTION TEAM REPRESENTATIVE

DEPARTMENT REPRESENTATIVE

## 6/ SAFETY RULES AND REGULATIONS

This paragraph outlines some of the broad safety rules and regulations which are presently enforced at General Dynamics/Astronautics and will be applicable to the R-I-F-T safety program. More detailed and specific rules and regulations will be developed as the program progresses.

### a. General

1. Personnel present during hazardous operations will be held to an absolute minimum.
2. Safety guards and devices furnished by the company must be used.
3. Danger and Warning signs will be posted if a specific hazard exist.
4. Horseplay, scuffling, running and practical jokes will not be permitted.
5. Protective clothing, such as hard hats, foot guards, rubber and asbestos gloves, rubber boots and respirators, is furnished by the company and must be worn on jobs requiring this type of protection.
6. Safety glasses, goggles or face shields must be worn where eye protection is necessary.
7. Women working in or required to go into the factory areas must wear slacks which extend at least to the calf of the leg in length.
8. Women must wear approved hair covering when working around revolving machinery or equipment.

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9. Loose or torn clothing, fore-in-hand ties, wrist watches and rings must not be worn when working around revolving machinery or equipment.
10. Barefoot sandals, slippers and other non-protective type of footwear are prohibited in the factory, laboratory or test area. Personnel normally wearing nonprotective footwear may use the main aisle while in the above mentioned areas.
11. Company provided tools are not to be modified by unauthorized personnel.
12. Hand tools are to be used only for the purpose for which they are designed.
13. Use of make-shift equipment will be prohibited.
14. Employees must not turn on, use, repair or operate any machine, tool, vehicle or crane, be it electrical, gas, steam, air or otherwise unless authorized by supervision.
15. Employees must not use any caustic or otherwise dangerous materials without approval from supervision.

b. Fire Regulations

1. All fires must be reported, regardless of size.
2. Sprinklers

Sprinkler heads shall be kept free of paint, covering etc.  
Do not use sprinkler heads or piping for supporting wires.  
Do not stack material within 18 inches of sprinkler heads.  
Sprinkler systems will be shut down on authority of, and by,  
Fire Department ONLY.

Clear access must be maintained at all sprinkler risers, test valves and drain valves.

**3. Standpipes**

Standpipe valves must be kept in a closed position.

Outlet caps must not be removed.

Connections and outlets must not be blocked or hidden from view.

**4. Fire Extinguishers**

Extinguishers shall not be moved or blocked from view or access.

If an extinguisher is used, request the Fire Department to replace it immediately.

Area coverage will be determined by the Fire Department.

Special tests, test areas, and hazardous operations or areas will be provided extra extinguishers coverage.

The Fire Department will hold demonstrations upon request of supervision on fire procedure and the use of fire extinguishers.

Extinguishers will be used for fires only.

G-1 Power Extinguisher is the only extinguisher to use on Magnesium fires.

**5. EXITS - FIRE DOORS - FIRE LANES**

Do not block exits or an aisle to an exit.

Fire doors and doors on interior stairwells must be kept closed at all times.

Elevator doors must not be locked open except when necessary to load or unload.

Fire lanes in buildings shall not be blocked.

Roads and roadways must be kept passable. If a road must be blocked temporarily, contact Fire Department before blocking.

6. HYDRANTS - VALVES - POST INDICATORS (P.I.S.)

Do not block fire hydrants and shutoffs, post indicator valves, sectional valves or fire department connections. Fire hydrants will not be used except by permission of the Fire Department.

Damage to hydrants, valves or post indicators must be reported to Fire Department immediately.

Report sprinkler alarms immediately to the Fire Department.

7. HOSE & HOSE LINES

Vehicles must not cross over hose lines

Location of hose, hose reels or hose cabinets must not be changed without permission of the Fire Department.

8. HAZARDOUS MATERIALS

Fire Department must be notified of the storage or major additions in storage of:

Flammable liquids and gases

Explosives

Toxic materials

Corrosive materials

Oxydizing agents

Water sensitive materials

(fire and explosion hazards)

Vehicles entering the plant with hazardous materials must be escorted by the Fire Department and a fireman standby maintained during transfer operations, if necessary.

Fire Department will furnish standbys for special tests or operations presenting explosion or fire hazards, when necessary or when requested.

Magnesium shall be stored in standard scrap metal tubs painted Traffic Yellow and marked "For Magnesium Only" in 2 inch Red letters.

No more than one tub of magnesium scrap shall be allowed to accumulate in an area.

**9. HAZARDOUS MATERIALS**

Flammable liquid waste shall be emptied into a suitable labeled container for disposal. Flammable liquid waste shall not be emptied into sinks or pipes connected to sewer system.

**c. Eye Protection**

**Supervisor's Responsibility:** Supervisors of employees working in areas where there are eye hazards must familiarize themselves with eye protection requirements and will insist that employees wear provided eye protection. When a supervisor is in doubt about eye protection requirements he should consult with a representative of the Safety Section, Industrial Relations Department. Eye protection equipment, such as sterilized cup goggles face shields, respirators, safety spectacles and special purpose masks are available at the Tool Criba and Safety Criba.

**Employee Eye Protection Requirements:** Employees with monocular vision or serious visual defects shall wear approved eye protection at all times when they are in the plant. Employees wearing ordinary vision corrective glasses shall wear cover glasses goggles, face shields or prescription safety glasses when working around eye hazards. Approved eye protection shall be worn by employees exposed to or performing the following operations:

Metal working operations, such as sawing, turning, boring, shaping, milling, drilling, grinding, chipping, burring, polishing, buffing, etc.

Woodworking operations with high speed lathes, shapers, saws, disc-sanders and similar machines.

Welding, burring or cutting operations. The use of welding goggles filter lenses are to conform to the following shade specifications:

|                                     |          |
|-------------------------------------|----------|
| Arc weld over 400 amps              | Shade 14 |
| Arc weld 200-400 amps               | " 12     |
| Arc weld 75-200 amps                | " 10     |
| Arc weld 30-75 amps                 | " 8      |
| Arc weld up to 30 amps              | " 6      |
| Heavy gas weld and cutting          | " 8      |
| Medium gas weld and cutting         | " 6      |
| Light gas weld, cutting and brazing | " 5 & 4  |

Handling, pouring or exposure to molten metal or heat treating of solvents or chemicals. Full length face shields shall also be worn if necessary to protect the face.

Cleaning or blowing out castings, machined parts, motors or other objects with compressed air or steam under pressure.  
Working where there is danger from falling particles, solvents or other irritating or dangerous materials.

Breaking, cutting, or drilling concrete, brick, stone or other hard materials.

Use of steel head hammers on steel, including their use with steel chisels and punches and for nailing.

Installing "clecos" or similar spring-type skin fasteners.

Lighting gas or fuel oil furnaces and boilers.

Control board work where there is danger of electric flash.

Conducting tests involving pressurized systems.

Where light or heat of unusual intensity is artificially or mechanically created and where exposure to such conditions may constitute a hazard to ocular processes. The Safety Office should be contacted for advice concerning specific types of eye protection required.

Full face shields or hoods with shields shall be worn when handling liquid fuels and liquid gases.

Availability of Equipment: Sterilized cup goggles, face shields safety spectacles, special purpose masks and respirators will be available.

d. Entering Vehicle Tanks

Flush and purge the tank.

Only those persons who have been checked-out by the Safety Engineer, or his designated, in proper use of safety equipment



may enter the tank.

When entering the tank, wear a breathing mask connected to an individual air or oxygen supply. Self-contained breathing apparatus is not acceptable for this operation.

The Safety Engineer will specify the special clothing and cleanliness precautions for the area. A safety harness and a safety rope of suitable strength shall also be worn.

In addition to the personnel necessary to operate the air pump, etc., another individual shall be assigned the sole duty of handling the safety rope, making certain that the worker inside the tank is not in trouble, raising an alarm in the event of any trouble, and aiding the worker in leaving the tank if this becomes necessary. Also, this individual must keep a close watch on the activities inside the tank without exposing himself to any dangerous fumes that might possibly issue from the tank.

Whenever any deviations from the above procedure are required, they may be authorized only by the supervisor specifically in charge of the facility after he has considered the hazards involved.

**e. Toxic Materials**

Toxic materials include solvents, cleaners, fluxes, scaling compounds, thinners, acids, caustics, resin components of plastics, etc.

Eye protection or face shields shall be worn when handling toxic materials.

Protective clothing and respiratory equipment shall be worn when handling some of these materials. Contact the Safety Section for recommendations.

Employees must be given complete instructions on the use and handling of toxic materials.

Care must be exercised in the maintenance of safety equipment used in handling toxic materials. Repairs will be made only by the Safety Section.

Do not eat in areas where toxic materials are used or stored.

Smoking is prohibited in vicinity of toxic materials.

Handling and use of any toxic material shall conform to the manufacturer or vendor's recommendations.

Accumulations of magnesium dust or cuttings shall be frequently cleaned up placed in properly labeled, covered metal containers. Rags containing magnesium dust should also be placed in the containers.

Magnesium shall be worked only on machines which are used exclusively for magnesium, or machines which have been thoroughly cleaned of other metal chips or dust.

A machine which has been used to work magnesium shall be thoroughly cleaned before any other material is worked on it. Grinding wheels or saw blades which have been used to work ferrous metal must be thoroughly cleaned before they can be used to work magnesium.

If a shop frequently grinds or saws magnesium a machine should be designated for working of magnesium only. This machine should be labeled with a sign.

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Chrome-pickled magnesium must not be ground or buffed on a wire wheel.

Water soluble or acid oil must not be used as coolant for working magnesium.

Only sharp cutting tools with adequate clearance will be used for cutting magnesium. Greater clearance is necessary on magnesium cutting tools than on ordinary metal cutting tools. When cutting magnesium, heavy cuts will be made and cutting tool shall be immediately backed off when cut is completed whenever possible. Cutting tools must never be allowed to drag on magnesium without cutting.

Only equipment with automatic temperature controls shall be used in magnesium heating or heat treating operations, except in open flame heating of parts for forming.

Magnesium scrap must be kept free of water-oil emulsions.

Open flames, hot chips or other sources of ignition must be kept away from magnesium filings.

Dry cutting of magnesium shall be done at a speed of 500 surface feet per minute or less.

Magnesium must be rigidly chucked when machining to prevent chattering.

Sweaters or fuzzy or loose textured clothing must not be worn by employees grinding or sawing magnesium.

Approved aprons shall be worn by employees engaged in sawing, grinding, burring or otherwise working magnesium where fine particles are present.

The Fire Section shall be notified immediately in the event of a fire in which magnesium is involved.

Shop personnel shall use only the dry powder chemical fire extinguishing agent furnished by the Fire Section for fighting of magnesium fires. (The Fire Section may use other extinguishing agents as necessary.)

Supervisors shall be responsible for maintaining an adequate supply of approved fire extinguishing agent in areas where magnesium is worked.

Titanium in finely divided form, finely milled cuttings, etc., should be treated in much the same manner as magnesium in regard to fire hazard.

f. Liquid Hydrogen

General Properties

Chemical Composition - Hydrogen,  $H_2$ . The hydrogen molecule exists in two forms (ortho and para) depending on the relative direction of spin of the two atoms. In the past, storage difficulties were incurred with the liquid because of the heat released as the ortho slowly but spontaneously changed to para hydrogen. The current use of catalysts at production facilities has eliminated this problem by allowing almost pure para hydrogen to be produced in the liquid form.

General Appearance - High purity liquid hydrogen is a transparent, colorless, odorless liquid. When in an observable condition, it is usually boiling vigorously (because of its low boiling point) and creates a voluminous vapor cloud when exposed to the atmosphere.

**Chemical Nature** - Liquid hydrogen is non-toxic and relatively inert except in the presence of oxidizers. When allowed to evaporate, it becomes highly combustible with air over a relatively wide range of mixtures.

Physical Properties

|                                                 |                             |
|-------------------------------------------------|-----------------------------|
| Boiling Point                                   | -423°F                      |
| Freezing Point                                  | -435°F                      |
| Density at -423°F                               | 4.4 lb/ft <sup>3</sup>      |
| Auto Ignition                                   | 1076 °F                     |
| Flammability Limits in Air (H <sub>2</sub> gas) | 4.0 to 74.2% H <sub>2</sub> |
| Viscosity at -423°F                             | 140 micropoise              |

Vapor Pressure

Pressure, psi

|      |           |
|------|-----------|
| °F   | 1.03 1.94 |
| -433 | 14.7      |
| -423 | 23.7      |
| -420 | 162       |
| -402 |           |

**Solubility** - With the exception of helium all known substances are essentially insoluble in liquid hydrogen at temperatures below its boiling point.

**Stability** - Liquid hydrogen is a chemically stable substance. Because of its low boiling point it is physically stable only when stored under suitable conditions. When stored in properly designed containers, the 24-hour evaporation rate may be as low or lower than 1.5 per cent for a 1,000 gallon container.

**Compatibility** - Hydrogen in either liquid or gaseous form will react violently with strong oxidizers, such as oxygen and fluorine, and will ignite with a minimum of energy.

As with most cryogenic fluids the effect of low temperature on material properties is extremely important. Mild steels and most ferrous alloys lose ductility at liquid hydrogen temperatures and become brittle. Also the severe changes in temperature that will occur can cause stress concentrations that must be taken into account in equipment design.

**Hazards**

**General** - Since hydrogen is non-toxic, the chief danger to health lies in the extreme cold when in the liquid form and from fire due to its flammability.

**Liquid** - The main hazard of the liquid arises from its coldness. Serious "burns" can occur when the skin or other parts of the body are exposed to liquid hydrogen temperatures by contact with pipes, valves, etc., or with the liquid itself.

**Vapor** - Since the vapor is extremely flammable, a serious fire hazard always exists when hydrogen vapors are in the area. Hydrogen does not support life and hence can cause death by the exclusion of oxygen.

**First Aid, Self Aid, and Medical Treatment** - Parts of the body which have come into contact with liquid hydrogen should be treated as for frostbite. Extensive and severe burns should be kept sterile and should receive medical attention as soon as possible.

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### **Fire Hazard**

**General** - When no impurities are present, hydrogen burns with a colorless invisible flame. Burning can be initiated with a minimum of energy and can take place with hydrogen-air mixtures containing as little as 4 per cent or as high as 74 per cent hydrogen.

**Types** - With unconfined hydrogen-air mixtures, rapid burning generally takes place when initiated by a spark or flame. In confined areas or when ignition is accomplished by a shock source equivalent to a blasting cap or a small explosive charge, a detonation, or an explosion, of the mixture could occur.

**Control** - The most effective control of hydrogen fires is the shutting off of the supply. Properly designed equipment should make this effective in case of most pipeline failures. Small fires, as from minor gas leaks, can be controlled effectively by the use of steam. If hydrogen flames are extinguished, the liquid will continue to vaporize and form a cloud of combustible gas. If this cloud should be ignited, it might cause more damage than the original small fire would have caused. Where large spills occur, vacate the area over a considerable distance (at least 400 ft. from the source). Adjacent structures may be sprayed with water for their protection. It should be emphasized that the outer limit of the flame, or fire, cannot generally be seen.

### **Explosion Hazards**

**General** - Liquid hydrogen does not normally present an explosive hazard when it evaporates and mixes with air in an unconfined space. The explosive hazard exists when the mixture is confined, or partially confined, or when it is ignited with a shock source initiator such as TNT. Explosive hazards also exist when oxygen enriched solid air or when strong oxidizers, such as oxygen or fluorine, are present. Pressure rupture, with severe consequences, can occur when the liquid is held in a closed system with no refrigeration. Hydrogen cannot be maintained as a liquid if its temperature rises above -400°F regardless of confining pressure. Liquid hydrogen trapped between valves can cause violent rupture of the pipe while loss of refrigeration can cause a storage tank to rupture if the pressure is not relieved by suitable devices.

**Prevention** - All sources of ignition should be kept away from areas where liquid hydrogen is being stored or handled. This means no smoking, use of explosion proof electrical equipment and spark proof tools, and proper grounding of equipment to remove static electricity.

**Venting** of hydrogen vapors should be accomplished at a remote location and storage tanks and other containers should be kept under positive pressure to insure that air does not enter the system. Enclosures of any type that would allow trapping of hydrogen should be either eliminated or ventilated.

**Pressure rupture** of equipment can be avoided by the proper use of pressure relief valves and blow-out disks. Pressure gages should also be used.



### **Safety Measures**

**Education of Personnel** - The following subjects shall be explained to all personnel working with liquid hydrogen handling, transfer, and storage:

- a. Nature and properties of hydrogen in both the liquid and gaseous phases.
- b. Approved materials which are compatible with liquid hydrogen.
- c. Proper equipment and its operation.
- d. Use and care of protective equipment and clothing.
- e. First aid instructions

Trained supervision of all potentially hazardous activities involving liquid hydrogen is essential.

### **Personal Protection**

**Hand and Foot Protection** - Gloves may be of leather or asbestos depending upon the job requirements. They should be loose fitting for quick removal but not of the gauntlet type. Preferably sleeves should be rolled down over the gloves to reduce chances of liquid collecting inside the glove.

Footwear shall be of leather and preferably high-top, but easily removable, to prevent liquid hydrogen from entering in the event of spillage. In all cases, pants legs shall be worn outside and over the shoe tops. Where soles of shoes have been exposed to the liquid, the footwear should be removed immediately. Heat soak through the soles may cause cold temperatures to reach the feet later on, causing frostbite.

**Head, Face, and Body Protection Requirements** - Head and face protection (face shield and cap) shall be worn by personnel handling liquid hydrogen.

Flame resistant and light colored coveralls must be worn by personnel working with liquid hydrogen because of the fire hazard.

**Transfer and Storage**

**General** - Both fixed or mobile containers for liquid hydrogen should be of approved design, materials and construction. An adequate water supply or fire extinguishers must be available for fighting fires (of combustibles other than hydrogen). Approved safety type personnel showers and fire blankets must be properly located for immediate use in an emergency. Protected areas for personnel safety during combustion of hydrogen spilling from either large storage tanks or pipelines should be provided.

**Materials** - The ability of materials to maintain satisfactory physical properties and to withstand thermal stresses caused by large temperature changes during cool down or warm up is of prime importance.

**Metals** - The ferrous alloys, except the austenitic nickel-chromium alloys (18-8 stainless steel series), lose their ductility when subjected to the low temperatures of liquid hydrogen and become too brittle for this application.

The following metals are generally acceptable for service with liquid hydrogen:

- a. 18-8 stainless steel series
- b. Copper
- c. Bronze
- d. Brass
- e. Monel
- f. Aluminum
- g. Everdur

Lubricants - Lubricants are generally not practical in the presence of liquid hydrogen since they solidify and become brittle at the temperature of the liquid. Where "O" rings are used in fittings, vacuum grease is satisfactory.

Non-Metals - The following non-metals are satisfactory for use with liquid hydrogen:

- a. Teflon
- b. Kel-F
- c. Asbestos impregnated with Teflon

#### Equipment

Containers - Liquid hydrogen may be stored in either fixed or mobile tanks of proven design and materials. Storage and shipping containers designed for non-cryogenic fluids should not be used in this service. Storage tanks should be tested in accordance with the provisions of applicable ASME, ASTM, or ICC specifications for unfired pressure vessels, to ensure against any material or fabrication defects. Materials used for pressure vessels containing liquid hydrogen should be impact-tested in accordance with paragraph UG-84 of Section VII of the ASME Code for Unfired Pressure Vessels.

Containers for shipment, storage, and transfer of liquid hydrogen should be fabricated in accordance with the physical and structural requirements of the service to which they are expected to endure. The containers should be insulated and vacuum jacketed to prevent rapid vaporization. The inner storage tank should be of welded construction and equipped with an adequate pressure relief valve for control of maximum pressure and a rupture disk to relieve unusually fast pressure buildup. Insulation such as evacuated perlite or santocel is acceptable. The insulation material should be compatible with liquid oxygen since failure of the outer tank might allow air to condense and mix with it. If liquid nitrogen is used as a coolant, proper relief valves, rupture disks and venting should be incorporated in the design.

**Pipes and Fittings** - Pipes and fittings shall be of the approved materials and construction and shall be hydrostatically tested at the prescribed pressures. Welded and flanged connections are recommended. Utectic brase procedures are also satisfactory with stainless steel. Threaded connections, particularly where directly exposed to liquid hydrogen temperatures, should be avoided.

**Pumps** - Only pumps and shaft seals specifically designed and qualified by test for liquid hydrogen should be used for this service.

**Valves** - Globe, gate, plug, or ball type valves may be utilized; however, they must conform to particular specifications necessary for use with liquid hydrogen. Valves must be capable

of being purged efficiently and have an adequate packing design to provide good sealing and to prevent plugging of condensation of air.

**Main Storage**

**Buildings** - Enclosures of any kind for large storage tanks should be avoided. All storage tanks for liquid hydrogen shall be surrounded by a dike large enough to contain 10 per cent more than the capacity of the storage vessels. The diked area should be covered to a depth of 6 inches with 1 to 1 and 1/2 inches crushed rock.

**Areas** - All main storage tanks and containers shall be located with due regard to the quantity-distance tables established by the service using the facility.

**Housekeeping** - No smoking, sparks, or open flames should be permitted in storage areas. The area shall be kept free of all other combustibles, and periodic inspection shall be enforced to ensure good housekeeping practices.

**Ready Storage** - The provisions and regulations covering main storage shall apply without exception to the ready storage.

**Transfer Procedures** - Operational procedures will be defined by the cognizant authority or by the manufacturer of the hydrogen equipment. All operating personnel shall have complete and thorough instruction prior to operating the equipment. All valves, pumps, switches, etc., shall be identified and tagged.

### **Transferring To and From Storage**

**Tank Cars and Motor Vehicles - Suppliers of liquid hydrogen will furnish loading and unloading instructions as part of their service. The users shall be instructed by the supplier in the proper use of the equipment.**

**Storage Tanks - The necessary procedures for transferring to and from storage tanks shall be based on specific tank design and the requirements of both the user and supplier.**

**Tanks should be cleaned to remove solid particles such as welding slag and dirt to prevent plugging of strainers or valves. If liquid cleaners are used, all traces of liquid must be removed before introducing hydrogen.**

**Before introducing liquid hydrogen, the system must be thoroughly purged. (The only substance which can be left in the system other than hydrogen is helium.) Purging shall involve evacuation of the air followed by breaking the vacuum with nitrogen gas. This shall be repeated until the concentration of oxygen in the tank is well below any combustible limit (4.0%  $O_2$  by volume) then re-evacuated and broken with hydrogen gas.**

**Venting of storage tanks shall be accomplished at a height of at least 30 ft. from the ground and at a remote location. Purges of steam or nitrogen should be available for extinguishing fires in stacks where venting rates are low. For continuous venting rates in excess of 30 lb/min, burning of the gas should be accomplished.**

**Spills, Leaks, and Decontamination** - The principal danger from a spill or leak is fire. Proper ventilation acquired generally by not enclosing the storage areas and provisions for enhancement of evaporation will help to reduce the fire danger. There is no efficient means of decontamination other than rapid vaporization and dilution with the air.

**Shipping**

**Applicable Laws** - According to "Agent H. A. Campbell's Tarrif No. 10, Interstate Commerce Commission Regulations for Transportation of Explosives and Other Dangerous Articles by Land and Water . . . .," liquid hydrogen is not to be offered or accepted for transportation. Special permits have been obtained by the Air Force, however.

**Shipping Containers, General** - Shipping containers are insulated and vacuum jacketed. As in storage tanks proper pressure relief valves and rupture disks are mandatory. Shipping over long distances may require venting prior to reaching the destination. Safe procedures involving the venting of hydrogen in remote areas shall be followed.

**Shipping Containers, Manufacturer's Specifications** - The design of a semitrailer for transportation of liquid hydrogen is given in "R & D M32U-1", Wright Air Development Center, Directorate of Development, Aeronautical Accessories Laboratory. Additional engineering information may be obtained from laboratories and producers experienced in cryogenic work.

**Loading and Unloading Instructions - Producers shall supply loading and unloading instructions as part of their service.**

**SAFETY PRECAUTIONS**

**All personnel shall be familiar with**

- a. Nature and characteristics of liquid hydrogen.**
- b. Safety features of the equipment and facilities.**
- c. Fire regulations**
- d. Proper operating procedures**

**Approved clothing including face shields and gloves shall be worn where specified.**

**Always provide good ventilation and allow no ignition source of any type to be brought into the area.**

**Pressurization systems must have a positive method of relieving the pressure before being placed in operation.**

**SAFETY RELIEF VALVES**

**Systems shall be equipped with at least one safety relief valve.**

**A valve must be installed on a vessel to be pressurized or in piping system downstream from air or gas supply.**

**Valves shall be set to 10% above operating pressure of the system.**

**Seats and discs of safety valves shall be of suitable corrosion-resisting material.**



## GAGES

Where possible, a gage shall be installed which will indicate the amount of pressure in the system.

Gages shall be equipped with blowout backs, disc or vented hole of sufficient capacity to relieve pressure.

Be positive that gage scale is sufficient for pressures involved.

Gages shall not be continuously operated above 75% of scale range.

Where gages are subjected to surge above scale, a dampner or oriface should be installed at gage connection.

## FLEXIBLE HOSE

Flexible hoses shall be inspected and tested at least every six months.

Hoses shall be proof pressure tested to  $1\frac{1}{2}$  times the operating pressure and shall indicate the operating pressure.

Damaged hoses shall be repaired immediately and retested. If they cannot be repaired they must be discarded.

Safety chains shall be used at the ends of hoses.

## PIPELINES

Pipe lines and fittings shall be proof pressured to  $1\frac{1}{2}$  times operating pressure.

If pipe lines and fittings are positioned where they may be struck or are in a regular working area, they must be shielded.

Lines shall be firmly secured every 24 inches.

Lines extending from fittings shall be secured no more than 4 inches from each end of the fitting.

Securing units such as clips, etc., shall be of the proper size and design. Never use units that are larger than pipe and tubing.

**TESTING SYSTEMS**

Proof pressure systems to 150% of the maximum working pressure.

Do not attempt to tighten or loosen a fitting while system is pressurized.

Do not expose personnel to high pressure lines. If absolutely necessary that personnel work in close proximity to lines, anchor lines and cover with angle irons.

Refer to Manufacturer Specification on operations of fittings, pipe lines or tubing, gages and relief valves.

Do not expose personnel to system while proof pressuring.

The system shall be checked at appropriate intervals for corrosion, abuse and fatigue.

Pressure test areas shall be roped off and warning signs, "Pressure Test in Progress," posted.

Relief valves shall be activated periodically to insure proper functioning. Frequency of testing shall depend upon climatic condition and application.

Valves must be tested at least once a year.

ANY WORK PERFORMED, e.g., EXAMINATION, LEAK CHECKING, FUNCTIONAL CHECKING, ETC., ON VESSELS, COMPONENTS OR SYSTEMS, SHALL BE ACCOMPLISHED ONLY AFTER THE AFOREMENTIONED HARDWARE HAS BEEN PRESSURIZED TO 150% OF DESIRED PRESSURE.

**g. Electrical**

Make-shift electrical devices are forbidden.

Pull switch to "off" position before leaving machine.

Always "lock out" switch when working on machine.

Keep covers installed on all boxes, fittings and enclosures.

Switches and panel boards shall be located for easy access.

Keep electrical cords from floors.

Do not use flammable solvents for cleaning electrical equipment.

Only qualified electricians shall install or repair electrical equipment.

Never work alone in an exposed High Voltage Area.

High Voltage Areas shall be posted.

All test setups must have a power disconnect switch

Keep one hand clear when handling energized parts or wiring.

Check wiring for short circuits, meters for adequate ranges and fuses for proper size before applying power.

Never handle energized electrical equipment while standing in water or on a damp surface.

Energized electrical parts are dangerous. Make sure surfaces are insulated if you must handle.

Only approved power cords will be used for connecting equipment to power sources.

Capacitors shall be discharged properly according to Standard Electronic Practices.

Do not wear jewelry around electronic equipment in operation.

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While engaged in electronic repair to circuits with power-on, hang a "High Voltage" sign near or around equipment.

Horseyplay will not be tolerated.

Extreme care must be taken in handling Cathode Ray tubes.

Wear a face shield and asbestos gloves.

Before measuring a circuit (power-off) with an ohmmeter make certain there are no voltage present. (Discharge capacitors)

When measuring voltages with power-on have one hand clear of equipment chassis.

It is recommended that a rubber floor mat be used while working on High Voltage of electronic equipment being repaired.

Do not probe hot circuits without using proper approved test equipment.

Voltage equipment shall be properly grounded.

Never work alone on High Voltage electronic equipment.

Use only plastic handle screw drivers.

**h. Welding**

Keep equipment clean, free of oil and in good condition.

Check equipment frequently for oxygen and acetylene leaks.

Open oxygen and acetylene valves slowly.

Purge oxygen and acetylene lines before lighting torch.

Keep heat, flame and sparks away from combustibles.

### **Personal Safety**

Keep equipment in good condition.

Never use oxygen to dust off clothing or work.

Use a spark lighter or pilot light to light torches.

#### **NEVER USE MATCHES**

Always wear goggles with suitable filter lenses when using a torch.

Wear leather or asbestos gloves, aprons, suitable shoes and other protective clothing.

Make sure that your clothing is not oily and the pockets and cuffs are not open and ready to receive sparks or hot slag.

### **Torches and Regulators**

Do not work with defective equipment. Keep your equipment clean.

Do not use oil or grease on torches or regulators.

Inspect connections and seating surfaces before use. Faulty connections are apt to cause fire or flashbacks.

Make sure the proper regulator is used for the specific gas to be used.

Never use a torch as a hammer to knock slag from work.

### **Hose:**

New hose is dusted inside with talc. Blow this out before using.

Hoses should be color coded for identification:

- a. The generally recognized colors are red for acetylene and other fuel gas hose; green for oxygen hose, and black for inert gas and air hose.

**Don't use frayed hose**

**Examine hose before starting welding operation for leaks.**

**Keep oil and grease away from hose. Do not repair hoses with tape.**

**Setting Up:**

**Before connecting regulators to cylinders, crack the cylinder valve carefully to blow out any foreign matter. Be careful not to crack a cylinder near other welding, sparks or open flame.**

**Make connections using wrenches designed for that purpose. Never force connections.**

**Stand to one side of the regulator gage when the cylinder valve is opened. Open valves slowly.**

**Never open an acetylene cylinder valve more than  $1\frac{1}{2}$  turns - but open oxygen cylinder valves wide. By opening oxygen valves wide, the clearance around the stem is sealed and leakage is prevented.**

**Leave acetylene valve wrench in position when valve is open.**

**This will facilitate quick closing in an emergency.**

**Use soapy water to locate a leaky connection. Never use flame.**

**Adjusting Pressures:**

**Use manufacturer's charts as a guide to obtain correct pressures.**

**In adjusting oxygen pressure, first be sure that the torch acetylene valve is closed. Open the torch oxygen valve.**

Adjust oxygen regulator until low - pressure gage indicated proper pressure while torch valve is open and oxygen is flowing through the tip. Close torch oxygen valve.

In adjusting acetylene pressure, first be sure that the torch oxygen valve is closed. Then follow same procedure as for oxygen.

**Shutting Down:**

When shutting down for a brief interval, place the hose and torch so they will not be damaged or disturbed.

Do not leave pressure in hoses when leaving the area. Shut oxygen and acetylene off at the cylinders.

Keep torch valves closed when not in use.

Never leave regulators attached to cylinders for extended periods of shutdown.

Always make sure the cylinder valve is tightly closed before removing regulator.

Drain gas from regulator before removing from bottle.

For shutdowns over an extended period, disconnect apparatus and stow it to prevent accidental damage and unauthorized personnel from using equipment.

**i. Machine Operations**

Always wear eye protection when operating machines.

Use a machine only if you have been authorized to do so.

Be sure guards and safety devices are in place and are in working order

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When starting a machine, make sure no one is working around it. Respect lockout tags.

Make only the adjustments which are part of your job. Stop the machine before making an adjustment unless otherwise instructed.

Use a brush or hook - not hands or an air hose - for cleaning away chips and cuttings.

Stop the machine when leaving the work area.

Run a machine as instructed. Don't use shortcuts. Run at established operating speed.

Keep the work place orderly - the floor clean, dry and safe.

Short sleeves - will be worn where climatic condition permits.

(Deviations may be necessary at certain off site bases.)

Do not wear gloves, unless authorized by supervision.

Keep your mind on your work. If you must talk to someone, step back from the machine.

Horseplay is prohibited.

Stop machine and cutoff the electrical power when machine is being oiled.

If the machine is not operating smoothly, shut it down and notify the supervisor.

Use common sense and keep your fingers where they belong.

Long ties shall not be worn. Wedding bands, properly taped, are permitted.



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**j. Cranes**

Cranes will be manipulated only by authorized operators, crane repairmen or inspectors. Bridge cranes will be designed to have the following safety factors based on full rated loads.

- a. Load hook not less than ten (10)
- b. Gear and hoist shafting not less than eight (8)
- c. Other parts not less than five (5)
- d. Cranes handling hot metal not less than ten (10) throughout.

The load capacity of boom type cranes will be posted in a conspicuous place and will not be exceeded.

All cranes will be properly rigged with wire rope. Slings will be made from wire rope. Special slings and/or loads bars must be approved by the safety section.

All cranes will be equipped with an available warning system. Each cage will be provided with an approved fire extinguisher.

Cranes will be inspected once each thirty day. This inspection will include:

- 1. brakes
- 2. Rigging
- 3. Functional operation
- 4. Lift test

**k. Operation of Company Vehicles**

Personnel operating company vehicles must have a valid State Operator of Chauffeur's license in their possession and operate vehicles as prescribed by the Vehicle Codes of the State(s) in which they are required to drive. Suspension of driving privileges under the vehicle codes shall automatically suspend personnel from driving company vehicles.

Only operators authorized and checked out by supervision shall operate vehicles. When driving vehicles requiring an operators badge, the driver must wear the badge in full view.

An employee's physical code must be checked with Medical and Safety Departments before he may be assigned as a vehicle operator.

Car loaders must be parked with the forks flat on the floor or yard surface and with the motor off and the brakes set.

Under no circumstances will an operator leave the motor running on unattended equipment. Set Brakes.

Operators shall drive equipment in a forward direction except under the following conditions.

- a. When the load obstructs the operator's vision when he travels forward.
- b. When it is necessary to back into position to turn around.
- c. When loading conditions dictate.

Forks of car loaders must be kept as close as possible to the yard or floor surface when the vehicle is moving a load.

When forks are not loaded and vehicle is in motion, forks shall be approximately 3 or 4 inches from the running surface.

ALL TRAFFIC SIGNS SHALL BE OBSERVED. A FULL STOP WILL BE MADE AT EVERY STOP SIGN.

The forks of a car loader shall not be used to elevate a workman to a higher level.

Do not exceed the maximum load limit of a vehicle. Supervision shall instruct operators as to the maximum load capacity of equipment.

Operators shall keep both hands on the steering wheel of the vehicle they are driving, except when using hand signals.

Passengers can ride only on equipment where a seat is provided.

Riding car loader prongs is prohibited.

A red flag shall be attached to the end of loads extending beyond the end of a truck bed or trailer.

Loads shall be secured and will not extend beyond the sides of a truck or trailer unless authorized by a supervisor.

The driver of a vehicle shall not follow another vehicle more closely than is reasonable and prudent, having due regard for the speed of such vehicle.

One vehicle will pull no more than six trailers in a train, nor more than twenty yellow trash buggies.

Operators shall check their equipment at the beginning of each shift. Under no circumstances will they operate defective equipment.

Report defects to supervision. Check closely for dripping oil.

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Do not attempt repairs.

Compressed gas cylinders are to be transported in cylinder racks and must be properly secured.

Vehicles shall be operated at a safe speed consistent with surrounding conditions. Stunt driving and horseplay is prohibited.

Operators shall keep feet on the foot controls or floor board surface at all times.

Keep doors closed or chains hooked when vehicle is in motion.

Remove keys when parked to prevent unauthorized persons from driving vehicles.

Women are not allowed to ride on electric trucks, scooters, hysters, jeeps or trucks of any kind.

UNDER NO CIRCUMSTANCES WILL UNAUTHORIZED PASSENGERS BE ALLOWED TO RIDE IN COMPANY VEHICLES.

Keep to the right hand side of roads and aisles.

Be sure there is sufficient clearance before entering close quarters.

Do not leave trucks or trailers parked in aisles.

Drive carefully at all times. Surrounding conditions should dictate the degree of caution required. Speed limit on plant property is 15 M.P.H. and inside buildings, 5 M.P.H.

1. Acknowledgement

Section 6 was in large extracted from the document Convair/Astronautics Safety Rules and Regulations by A. W. Wright.