AF/SSD-TR-61-6 R-3130

MECHANICAL SYSTEM DESIGN-CRITERIA MANUAL FOR HYDRAZINE

ROCKETDYNE
A DIVISION OF NORTH AMERICAN AVIATION, INC.
6633 CANOGA AVENUE, CANOGA PARK, CALIFORNIA

CONTRACT AF33 (616)-6939
PROJECT No. 3148
TASK No. 30196

SEPTEMBER 1961

ROCKET TEST ANNEX
SPACE SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
EDWARDS AIR FORCE BASE, CALIFORNIA

80

AF/SSD-TR-61-6 R-3130

MECHANICAL SYSTEM DESIGN-CRITERIA MANUAL FOR HYDRAZINE

Rocketdyne
A Division of North American Aviation, Inc.
6633 Canoga Avenue, Canoga Park, California

Contract AF33(616)-6939
Project No. 3148
Task No. 30196

September 1961

ROCKET TEST ANNEX
SPACE SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
EDWARDS AIR FORCE BASE, CALIFORNIA

FOREWORD

This manual is one of a group of four design-criteria manuals prepared under Contract AF 33(616)-6939, Supplement 1, PN 3148, TN 30196. The administrative and technical direction of this effort was provided by Messrs. F. S. Forbes, J. Marshall, and J. H. Smith of the AFFTC, Edwards Air Force Base, California. The manuals were prepared by the Analysis and Equipment Group of the Rocketdyne Engineering Department, and the Rocketdyne Facilities Engineering Department.

The design-criteria manuals were titled and identified as follows:

AF/SSD-TR-61-6	Mechanical System Design-Criteria Manual for Hydrazine
AF/SSD-TR-61-5	Mechanical System Design-Criteria Manual for Nitrogen Tetroxide
AF/SSD-TR-61-4	Mechanical System Design-Criteria Manual for Chlorine Trifluoride
AF/SSD-TR-61-3	Mechanical System Design-Criteria Manual for Pentaborane

A group of four propellant handling manuals were also prepared under Contract AF 33(616)-6939, Supplement 1, PN 3148, TN 30196. These manuals were titled and identified as follows:

AF/SSD-TR-61-7	Hydrazine Handling Manual
AF/SSD-TR-61-8	Nitrogen Tetroxide Handling Manual
AF/SSD-TR-61-9	Chlorine Trifluoride Handling Manual
AF/SSD-TR-61-10	Pentaborane Handling Manual

ABSTRACT

This manual presents criteria for the design and fabrication of a hydrazine storage facility. Primary consideration is given to the integrity of the storage system, and personnel safety.

The properties of hydrazine affecting the selection, design, and fabrication of storage facilities are described and discussed.

The selection of compatible materials of construction and control equipment are discussed. Procedures for testing, cleaning, and inspecting the storage system, or components thereof, are reported. In addition, the reactivation of existing facilities for use with hydrazine are discussed.

CONTENTS

Foreword iii

Abstract iv

Introduction 1

1.0 Properties of Hydrazine 3

1.1 General Properties 3

1.2 Physicochemical Properties 3

1.3 Toxicity 4

1.4 Flammability and Reactivity 8

2.0 Site Selection 9

2.1 General 9

2.2 Meteorological Considerations 9

2.3 Quantity-Distance 10

2.4 References 11

3.0 Storage Area 12

3.1 General 12

3.2 Meteorological Concepts 13

3.3 Layout and Orientation 14

3.4 Propellant Storage and Transfer Systems 15

3.5 Diking and Retainment 20

3.6 Safety and Fire Protection 21

3.7 Disposal 22

3.8 Electrical Concepts 23

3.9 References 24

4.0 Materials Selection 25

4.1 General 25

4.2 Compatible Materials 25

4.3 Materials Suitable for Limited Service 26

4.4 Unsuitable Materials 27

4.5 References 28

5.0 Equipment Design and Selection 30
5.1 General 30
5.2 Vessels 30
5.3 Piping Systems 31
5.4 Stainless-Steel Tubing and Fittings 38
5.5 Valves 38
5.6 Relief Devices 42
5.7 Regulators 42
5.8 Pumps 43
5.9 Filters 45
5.10 Air Pollution Monitoring 46
5.11 Level Gages 46
5.12 References 47
6.0 System Fabrication 49
6.1 General 49
6.2 Welding 49
6.3 Brazing and Soldering 51
6.4 Mechanical Joints 51
6.5 Inspection 53
6.6 References 55
7.0 Hydrostatic and/or Pneumatic Tests 57
7.1 Storage Vessels 57
7.2 Valves, Piping, and Fittings 59
7.3 Applicable Codes and Specifications 60
8.0 Cleaning Procedures 61
8.1 General 61
8.2 Degreasing 62
8.3 Descaling or Cleaning 63
8.4 Passivation 64
8.5 Drying and Handling 66
8.6 Inspection 67
8.7 Material Reference 68

9.0 Inspection and Maintenance 69
9.1 General 69
9.2 Inspection 69
9.3 Maintenance 71
10.0 Reactivation of Existing Facilities 73
10.1 Design Evaluation 73
10.2 Inspection of Usable Components 73
10.3 Rework and/or Cleaning of Usable Components 74
11.0 Appendices 75
11.1 Water Storage Capacity 75
11.2 Acceptance Standards for Welds 75
11.3 Specifications Criteria for the Design and
Fabrication of Facility Installations 77

ILLUSTRATIONS

1. Density of Liquid Hydrazine 5
2. Viscosity of Liquid Hydrazine 6
3. Vapor Pressure of Liquid Hydrazine 7
4. Schematic Representation of a Typical Hydrazine Storage Tank System 17
5. Flow Chart for Hydrazine in Schedule 40 Piping at 77 F 32

INTRODUCTION

This manual presents criteria for the design and fabrication of a hydrazine storage facility. These criteria have been derived from a comprehensive survey of current literature, and information accumulated by several contractors. Consideration is given to the establishment of facilities capable of handling propellant flowrates of up to 10,000 gpm, operating pressures of up to 3,000 psi, and for propellant storage of quantities as large as 5,000,000 pounds.

The advent of the use of high-energy propellants has introduced a need for storage and handling criteria for these propellants. The more conventional propellants, such as liquid oxygen and hydrocarbon fuels, are considered to be hazardous, but generally the hazard is limited to flammability. With most high-energy propellants, flammability is only a small portion of the handling and storage problem. Other important considerations arise from the unique chemical and physical properties of these propellants, such as:

1. Spontaneous reaction with air or other propellants (pyrophoricity, hypergolicity, etc.)
2. Chemical attack on common materials of construction
3. Formation of explosive mixtures with air or other chemicals
4. Toxicity

Because of these unique characteristics, it is essential that the designer of propellant systems be thoroughly familiar with the problem areas associated with each high-energy propellant - - hydrazine is no exception.

The information presented in this manual is divided into eleven sections. Each section contains information dealing with a specific subject, such as materials selection, cleaning procedures, etc. Some of the information presented, such as quantity-distance values, are subject to revision in the near future.

1.0 PROPERTIES OF HYDRAZINE

1.1 General Properties

Anhydrous hydrazine is a clear, colorless, hygroscopic liquid with an odor similar to that of ammonia. It is soluble in water, methanol, ethanol, ethylenediamine, unsymmetrical dimethylhydrazine, and other polar solvents. It is immiscible with nonpolar solvents. Hydrazine is a very strong reducing agent and is toxic. Its chemical formula is N_2H_4.

Commercial "anhydrous" hydrazine which is marketed for use as a rocket propellant contains a minimum of 97 percent hydrazine, the other constituent being primarily water.

1.2 Physicochemical Properties

	100 Percent N_2H_4	97 Percent N_2H_4 3 Percent H_2O
Molecular Weight	32.05	......
Boiling Point, F	235.9	239
Freezing Point, F	34.8	30
Specific Gravity	1.008 at 68 F	1.012 at 68 F
Density, lb/ cu ft	62.93 at 68 F	63.18 at 68 F
Vapor Pressure, psia	0.2 at 68 F	......
Viscosity, lb_m/ft-sec	6.54×10^{-4} at 68 F	6.58×10^{-4} at 68 F
Surface Tension, lb_f/ft	0.00456 at 77 F	......
Critical Temperature, F	716	......
Critical Pressure, psia	2130	....
Velocity of Sound in Liquid, ft/sec	6857 at 77 F	6755 at 77 F

Compressibility (adiabatic), sq in./lb_f	1.572 x 10^{-6} at 77 F	......
Compressibility (isothermal), sq in./lb_f	1.746 x 10^{-6} at 77 F	......
Flash Point (COC), F	126	......
Heat of Formation (liquid), Btu/lb-mol	21,600 at 77 F	......
Heat of Fusion, Btu/lb	170 at 34.8 F	......
Heat of Vaporization, Btu/lb	602 at 77 F	......
Heat of Combustion, Btu/lb	8346 at 77 F	......
Heat Capacity, Btu/lb-F	0.7358 at 68 F	......
Thermal Conductivity, Btu/hr-sq ft-F/ft	......	0.29 at 77 F

The density and viscosity of both anhydrous and commercial hydrazine as functions of temperature are presented in Fig. 1 and 2, respectively. The vapor pressure of anhydrous hydrazine as a function of temperature is presented in Fig. 3.

1.3 Toxicity

Hydrazine is a toxic substance which may be absorbed into the body by ingestion, inhalation, or through contact. Contact of hydrazine with any body tissues will produce an alkali-like burn. In addition to local irritating effects, exposure to hydrazine vapors will cause nausea, dizziness, and headache. Exposure to high concentrations affects the central nervous system resulting in hyperpnea, convulsions, and unconsciousness. Repeated exposures produce toxic damage to the liver and kidneys and to a lesser extent, anemia and lowering of blood sugar concentrations.

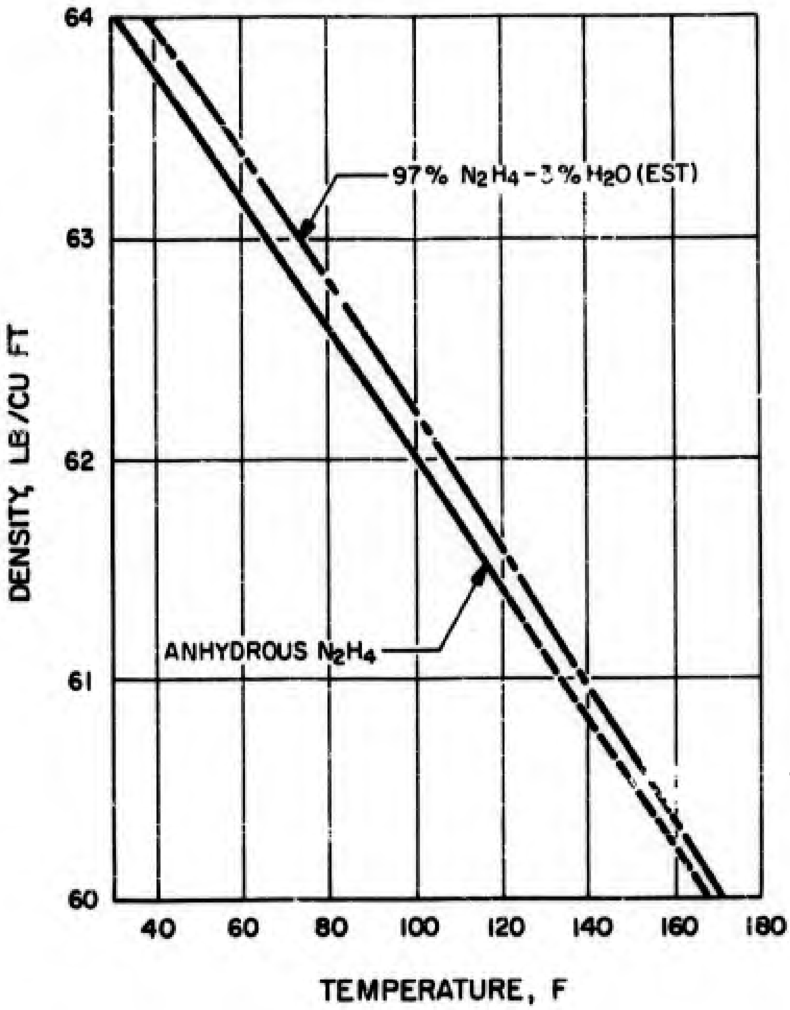

Figure 1. Density of Liquid Hydrazine

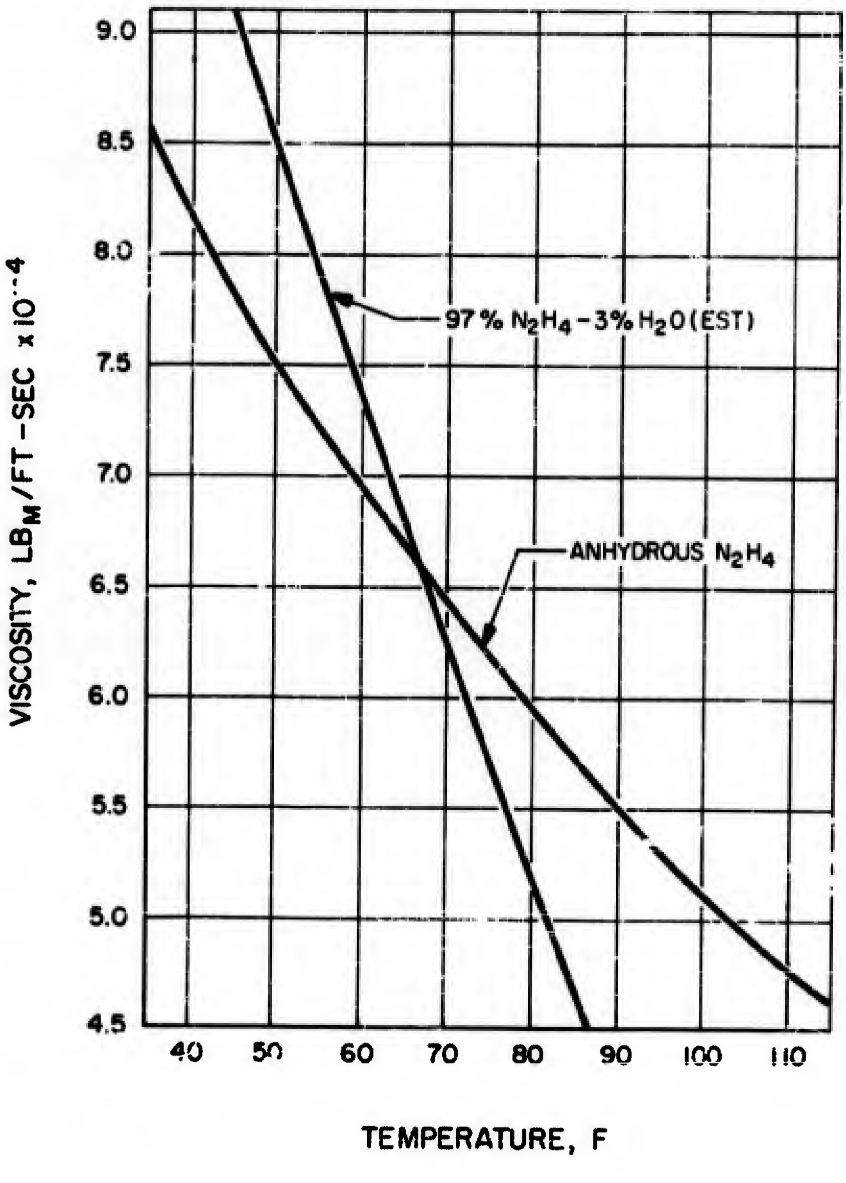

Figure 2. Viscosity of Liquid Hydrazine

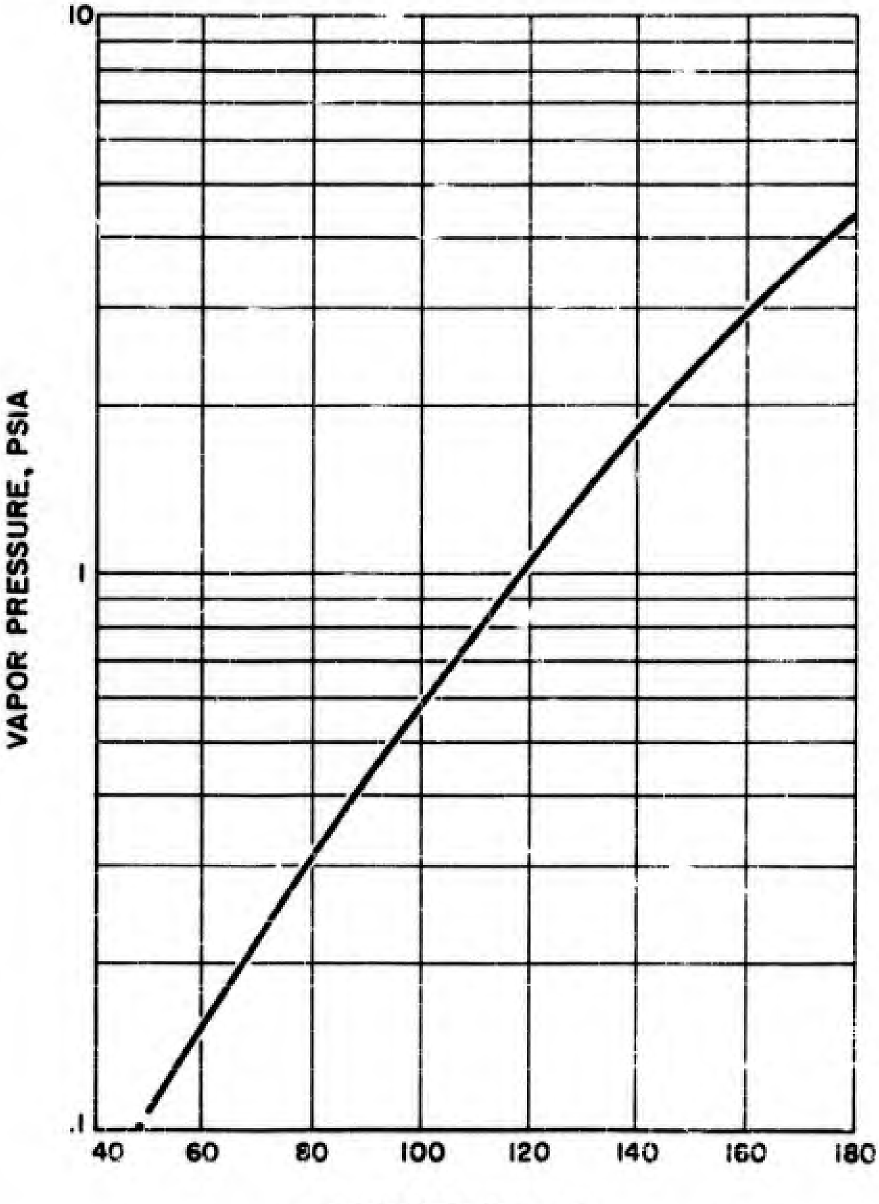

Figure 3. Vapor Pressure of Liquid Hydrazine

The American Conference of Governmental Industrial Hygienists (1960) established a maximum allowable concentration (MAC) for continued eight-hour daily exposures of 1 ppm. The detectable odor threshold varies from 3 to 5 ppm.

1.4 Flammability and Reactivity

Anhydrous hydrazine is a flammable, reactive liquid which is insensitive to mechanical shock. The flammability limits in air range from 4.7 to 100 percent, by volume. During storage, liquid hydrazine is maintained under an inert atmosphere (usually a gaseous nitrogen blanket) which reduces its flammability and reactive potential in air.

Hydrazine is a very strong reducing agent and therefore reacts with most oxidizing materials (including metallic rust) generaating large quantities of heat. It is hypergolic with nitric acid, concentrated hydrogen peroxide, nitrogen tetroxide, chlorine trifluoride, and other reactive oxidizers at atmospheric pressures. Under appropriate conditions, hydrazine acts as a monopropellant.

Hydrazine concentrations of about 40 percent or less in water are not combustible.

2.0 SITE SELECTION

2.1 General

Desert, mountain, or offshore island sites are most favorable for a toxic propellant facility. The desert sites are characterized by barren wasteland, strong surface winds, strong uplifting thermal currents, and low humidity. The population density of such an area is usually extremely low, and pollution of off-site public ground water can be easily controlled. The scarcity of water in such sites may force recovery, simultaneously reducing the water pollution problem.

The mountain sites usually possess consistent wind direction, extended wind duration, dispersive terrain, good soil stabilization, natural blast and noise barriers, good hydraulic gradients, and water availability. Pollution of off-site public ground waters may be possible at mountain sites.

Offshore island sites present the following advantages: intervening unpopulated areas, consistent wind direction, ideal drainage and disposal of contaminated propellant and waters. A decided disadvantage is the lack of overland communcations and transportation.

2.2 Meteorological Considerations

All atmosphere dispersal equations indicate that the ground level concentrations of gases, or smokes, in air are inversely proportional to the square of the height of release above an aerodynamically smooth plain if release is continuous, and inversely proportional to the cube of the height of release if release is instantaneous (Ref. 2.4.1). Thus storage areas should be located at the highest accessible elevations in such orientation that the prevailing wind in the area will carry vapors from spillage toward unpopulated areas or over the top of a ridge which elevates the effective height of release.

2.3 Quantity-Distance

Liquid hydrazine, both anhydrous and the hydrate, is classified by T.O. 11C-1-6 (Ref. 2.4.2) as a Group 4-C, Combustible (Nitrogen-Hydrogen Compounds). This technical order is the present military authority for establishing quantity-distance relationships. Table 1 gives the limiting distance values presently established for hydrazine storage. These distances are based on the fire explosion hazard of hydrazine and not the toxic hazard.

TABLE 1

QUANTITY-DISTANCE VALUES

Quantity of Group 4 Propellant		Barricaded Distance in feet to (*)		Unbarricaded Distance in feet to		
Pounds Over	Pounds Not Over	Inhabited Building Distance	Magazine Distance	Inhabited Building Dist.	Passenger Railroad Public Highway	Magazine Dist.(Z)
0	200	100	50	200	110	100
200	1,000	255	50	510	150	100
1,000	5,000	375	75	750	225	150
5,000	10,000	435	100	870	260	200
10,000	20,000	480	125	975	300	250

TABLE 1 (Continued)

Quantity of Group 4 Propellant		Barricaded Distance in feet to (*)		Unbarricaded Distance in feet to		
Pounds Over	Pounds Not Over	Inhabited Building Distance	Magazine Distance	Inhabited Building Distance	Passenger Railroad Public Highway	Magazine Dist. (Z)
20,000	50,000	700	150	1,400	420	300
50,000	**100,000	900	200	1,800	545	400
100,000	250,000	1,100	300	2,200	650	600
250,000	500,000	1,400	400	2,800	900	800
500,000	1,000,000	1,700	500	3,400	1,100	1,000

*Barricaded, earth-covered, revetted, or underground

**Maximum permitted for hydrazine

(Z) For distances from storages (except ready storages) to operating buildings use service building distances.

2.4 References

2.4.1 Meteorology and Atomic Energy, AECU 3066, July 1955.

2.4.2 Air Force General Safety Procedures for Chemical Guided Missile Propellants, T.O. 11C-1-6, 1956.

3.0 STORAGE AREA

3.1 General

A hydrazine storing facility may exist in the form of:

1. A singular area for the storage of hydrazine only
2. A common singular area for the storage of hydrazine and other fuels
3. An area complex for the storage of hydrazine and other fuels
4. An area complex for the storage of hydrazine and other propellants, including oxidizers

In addition, the facility may be located in an isolated area, or in the proximity of a test or launch installation.

The design criteria for each particular form of hydrazine-storing facility must be considered independently. This is necessary because each propellant in the facility requires special consideration. In addition, a facility located in the proximity of a launch or test installation, for example, is exposed to vibrational and thermal effects, which requires special consideration.

The design criteria presented herein pertains mainly to the design of a singular, basic facility for the storage of hydrazine only. Such a facility will be referred to as a hydrazine storage area, or simply, a storage area.

3.2 Meteorological Concept

The concept of establishing meteorological monitoring of activities capable of discharging toxic effluents into the atmosphere is well accepted. The precise nature of these activities, and the environment in which they are performed, determines the extent of meteorological control required.

Considering a storage and test complex as an entity, the contribution of the meteorologist is of the greatest importance in the planning and site selection phases. Working with the facility engineers, he must achieve a design and location which will guarantee that any release of toxic gases resulting from an accidental propellant spill of any conceivable magnitude will be reduced to relatively harmless concentrations by the time it reaches off-site population. These design and location criteria must be valid for the worst probable meteorological conditions.

It is obvious that when these protective criteria have been realized, there are no normal operational activities at a storage and test complex which could constitute any greater off-site hazard. In effect, this indicates that meteorological control is not required at the storage and test complex for the protection of off-site population.

On the other hand, to afford the maximum protection to operating personnel on or near the site, additional measures must be taken. Personnel exposure to toxic gases is minimized not only by proper and judicious use of safety clothing and breathing equipment but by:

1. The use of detection equipment in conjunction with alarm systems to warn of accidental releases

2. The performance of transfer and disposal operations under specifications established by competent meteorologists. These specifications are dependent, for the most part, upon the specific orientation of buildings, roads and offices, and would establish, primarily, the proper wind directions, wind speeds and time of day for safe operation.

It is recognized that no storage area would be completely independent, but that it would exist in conjunction with either a rocket launch or test installation. It is at the latter facilities, where the probability of massive toxic releases is so high, that a Meteorological Control Center would exist. The minor meteorological effort required for a storage area should be directed by this central control office.

Meteorological instrumentation required for a storage and test complex is basic, consisting of wind direction and speed transducers connected to recorders and hygrothermographs located in weather instrument shelters. The number and location of these instruments is a function of facility size and topography and is determined by the meteorologist as part of his site analysis.

3.3 Layout and Orientation

The storage area should be oriented so that the prevailing winds do not carry vent gas, vapor from leaks and spills, or vapor from disposal and treatment areas into work and service areas, parking areas, or heavily traveled roads.

The storage area arrangement and layout shall be in accordance with Para. 5 of Ref. 3.9.1. Provisons must be made to include not only the necessary equipment and facilities, but also for possible expansion. The storage area should be properly fenced.

3.4 Propellant Storage and Transfer Systems

3.4.1 Storage Tanks

Storage tanks and associated piping should be designed and fabricated as per Sect. 5.0 and 6.0 of this document. The materials of construction should be selected for compatibility with hydrazine per Sect. 4.0.

The storage tanks should be sized to receive at least twice the expected individual shipments, with at least 10 percent volumetric allowance for ullage. A nominal tank capacity of 20,000 gallons is recommended. All storage tanks and associated valves and piping should be located above ground to facilitate the detection of leaks. Tank supports and foundations should be designed with a minimum safety factor of 4, with due regard for local seismic and vibrational conditions. Each tank should be located within a separate retaining wall, dike, or revetment, sized to contain at least 1-1/2 times the tank capacity. Each tank should be electrically grounded and equipped with an adequately sized, remotely controlled, "fail-safe" vent valve. Storage tanks may be located as close as 8 feet to each other provided that adequate water spray coverage is available. All main tank connections should be made through the top portion of the tanks to reduce the possibilities of propellant spill.

A well must be provided at the bottom of the storage tanks to permit almost complete propellant drainage. The well may, in turn, be completely drained for cleaning purposes by providing an adequate tank connection.

A schematic presentation of a storage tank system is shown in Fig. 4. This system reflects most of the criteria presented above. The identification of the various components is as follows:

Component No.	Description
1	Valve, dike drain
2	Valve, tank well drain
3	Dike
4	Storage tank
5	Dip tube
6	Filter, product discharge
7	Valve, pump shutoff
8	Pump, transfer
9	Valve, tank product discharge shutoff
10	Valve, tank vent shutoff
11	Valve, discharge line purge
12	Valve, tank fill shutoff
13	Filter, tank fill
14	Valve, tank fill isolation

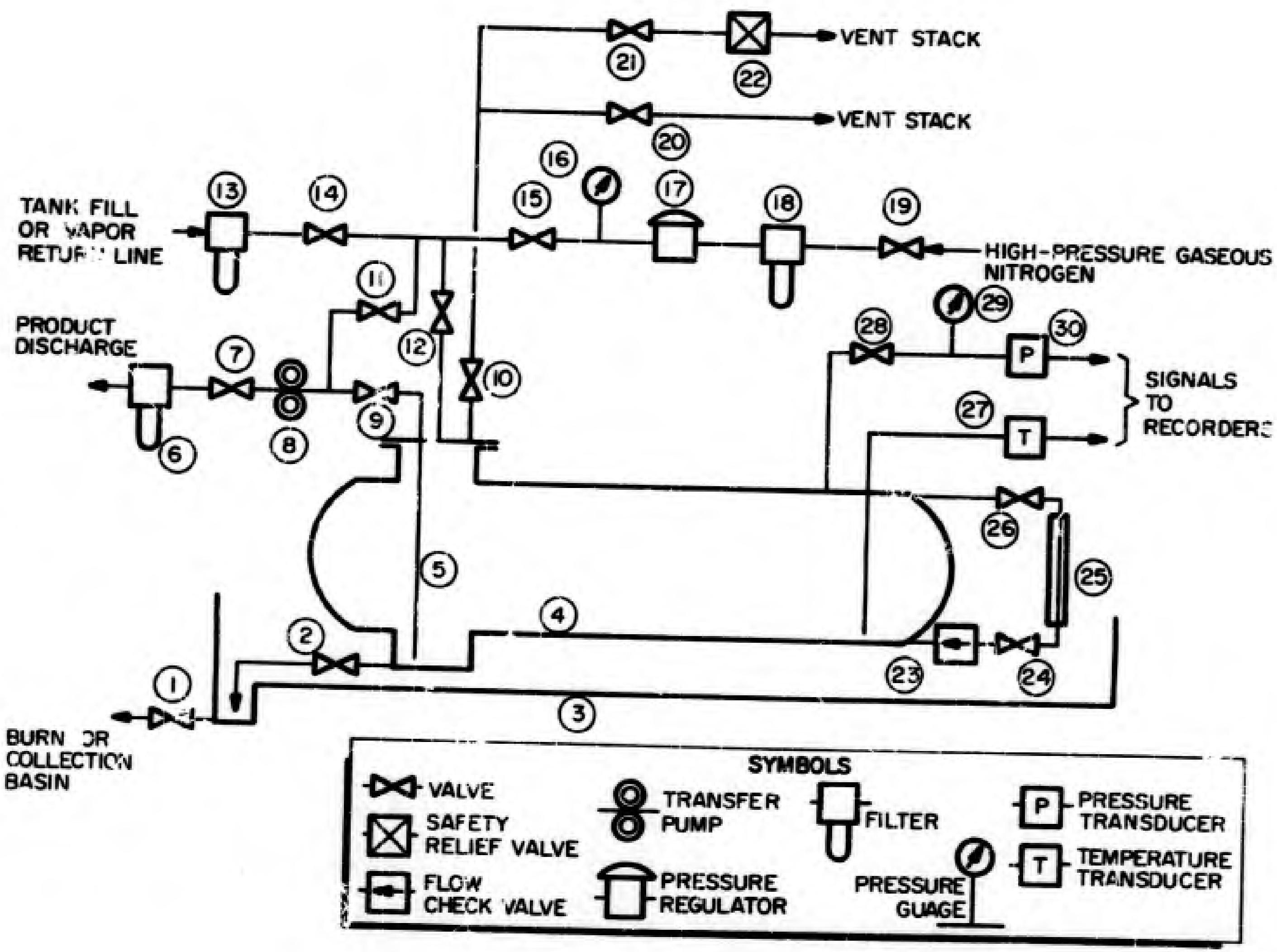

Figure 4. Schematic Representation of a Typical Hydrazine Storage Tank System

Component No.	Description
15	Valve, regulated gaseous nitrogen shutoff
16	Gage, regulated gaseous nitrogen pressure
17	Regulator, gaseous nitrogen pressure
18	Filter, gaseous nitrogen
19	Valve, high-pressure gaseous nitrogen shutoff
20	Valve, tank vent
21	Valve, relief valve shutoff
22	Valve, pressure relief
23	Valve, flow check
24	Valve, sight gage isolation
25	Gage, level indicator
26	Valve, sight gage isolation
27	Transducer, temperature
28	Valve, pressure sensing line shutoff
29	Gage, tank pressure
30	Transducer, pressure

3.4.2 Transfer Systems

Propellant transfer systems should be arranged and connected to permit safe and systematic transfer of hydrazine without loss or contamination. Pumps, valves, and lines should be sized to provide efficient transfer without excessive pressure loss. Materials of construction and fabrication methods, coupled with cleaning procedures, should be adequate for extended service in hydrazine. System components should be adequately and rigidly supported with due allowance for temperature changes. The possibility of propellant leakage can be significantly reduced by using all-welded pipe lines with flanged end connections. System components should be located within the diked area to facilitate spillage control. The inlet and discharge terminals of transfer lines should be valved. The transfer lines should be designed and installed to provide for adequate liquid drainage and purging.

The freezing point of commercial hydrazine is about 30 F, which is relatively high for transfer operations under cold climatic conditions. There are three methods of preventing hydrazine from freezing; two of these methods are within the regime of the designer. These methods are: (1) the addition of a freezing point depressant to the propellants, (2) insulation of the transfer lines, and (3) insulation plus tracing with heat elements, steam, or hot water. The best method of preventing hydrazine from freezing in the transfer lines appears to be that of insulating plus tracing with heating elements.

The use of a vent gas scrubber for hydrazine storage systems is not required. The vent and relief gases should be piped to a vent stack and released at least 60 feet from the highest working point in the area. The vent stack should be equipped with an appropriate flame arrestor.

Hydrazine can be unloaded reliably from the storage tanks by means of a transfer pump or by pressurizing the tank with gaseous nitrogen. The use of a transfer pump is preferred because: (1) it reduces the gaseous nitrogen storage requirements; (2) electrical power is readily available; (3) large quantities of the propellant can be transferred in a relatively short period of time; and (4) lighter storage tanks can be fabricated. For such applications, a reliable flange-mounted submerged pump offers merit since it requires no priming, is easily installed, and causes no external leakage.

The use of gas pressurization unloading should not be completely disregarded, especially when the propellants transfer rates are low. This system offers considerable advantages such as reliability, simplicity, and ease of operation and maintenance. In addition, since gaseous nitrogen is required at the storage area for purging and blanketing purposes, a separate gaseous nitrogen storage system is not required.

3.5 Diking and Retainment

Each hydrazine storage tank shall be installed within a separate dike, revetment, or walled area to retain spilled propellant. This containment should have a smooth and nonporous concrete or cement facing or lining to prevent contamination of ground water through percolation. The dike or retainment should be capable of retaining at least one-and-one-half times the tank capacity. The diking system should be designed so that it will gravity-drain into a burn basin, a collection basin, and a reclamation sump. These facilities can be interconnected by means of concrete channels and isolated as required by means of valves.

3.6 Safety and Fire Protection

Hydrazine fires can be controlled efficiently by spraying the fire with copious quantities of water. In this case, the water not only cools the surrounding equipment but also dilutes the hydrazine to form a noncombustible solution. (As mentioned previously, aqueous hydrazine solutions of less than about 40 weight percent hydrazine are not combustible.) For this application, water sprinkle nozzles are more efficient than the usually recommended fog nozzles, since the main effort is concentrated on diluting the hydrazine rather than removing heat.

The hydrazine storage area should be provided with a fire water loop system of ample and adequate size with strategically located hydrants. A sprinkler system must be included to provide remote-controlled water coverage to the storage tanks and unloading docks (Ref. 3.9.2). An adequate supply of water for fire fighting and washdown is imperative. Provisions should be made for replenishment of the total stored water within twelve hours, or less, without the use of portable or emergency equipment. Water may be either fresh, brackish, treated and recovered, or salt water.

The determination of the water storage capacity required at the hydrazine storage area is discussed in Sect. 11.0. Sufficient water storage capacity should be available to dilute the contents of at least one storage tank to below 40 percent hydrazine concentration, with a generous allowance for evaporation and spillage, and still leave a reserve capacity for cooling other storage tanks and systems and for personnel safety purposes.

Sprinkler systems should be protected from freezing in locations where temperatures may fall below 32 F. The spraying system should be fabricated of pipe not less than one inch in diameter and provided with a nozzle pressure of at least 50 psig.

The storage area should be provided with portable, chemical-type fire extinguishers. The carbon dioxide extinguisher is recommended for general use throughout the area.

The storage area should be provided also with a generous amount of strategically located safety equipment. This equipment should consist of safety showers, eyewash fountains, and fire blankets. Facilities must be available for the storage of personnel safety equipment.

The storage area should be fenced and equipped with appropriate warning signs, safety placards, and other equipment and techniques typical of good industrial practice.

3.7 Disposal

The hydrazine storage area must be provided with facilities for the safe disposal of hydrazine and contaminated hydrazine solutions. Hydrazine disposal can be accomplished by burning, reacting, or diluting. The burning operations can be performed in a rectangular, flat-bed type, burn basin. Hydrazine and hydrazine aqueous solutions containing over 40 percent hydrazine are combustible. For hydrazine concentrations below 40 percent, a miscible solvent or fuel can be added to render the solution combustible.

Hydrazine solutions, especially those containing less than 40 percent hydrazine, can be easily disposed of by reacting them with hydrogen peroxide. This operation can be performed in the collection basin. When the hydrazine concentration in the collection basin falls below that locally permitted, the contents of the basin should be drained into the reclamation sump.

Hydrazine solutions can be also disposed of by diluting with water until the hydrazine concentration falls below that locally permitted. This technique is particularly applicable when the hydrazine concentration is below 10 percent.

3.8 Electrical Concepts

All electrical installations throughout the storage area shall conform to the national, state, and local codes for the type of area and service involved. The area shall be floodlighted in accordance with good industrial and safety practices for the type of work involved. Electrical power distribution within the storage area shall be made through appropriate ducts, preferably underground. Adequate electrical receptacles shall be strategically located for maintenance purposes.

All vent stacks, storage tanks, and steel structures shall have integrally mounted lightning protection systems in accordance with Sect. 8 of Ref. 3.9.3. All storage tanks, pumps, loading points, electrical equipment, and propellant transfer lines shall be grounded and bonded electrically, in accordance with Ref. 3.9.2 and national, state, and local codes.

3.9 <u>References</u>

3.9.1 Air Force General Safety Procedures for Chemical Guided Missiles Propellants, T. O. 11C-1-6, 1956.

3.9.2 "The Chemistry of Hydrazine," by Audreth and Ogg, John Wiley and Sons Co.

3.9.3 Ordnance Safety Manual, ORD M7-224 (T.O. 11A-1-40C).

4.0 MATERIALS SELECTION

4.1 General

The following lists of materials and their behavior when exposed to hydrazine are largely the result of studies by Rocketdyne and others, and is based upon laboratory exposures under closely controlled conditions and experience in field use (Ref. 4.5.1 - 4.5.9)

4.2 Compatible Materials

When properly cleaned and prepared, the following materials can be successfully used in hydrazine systems.

4.2.1 Aluminum Alloys

1100 (2S)
2014, 2024
4043
5052
6061
6066
356 Castable
B356
Tens-50

4.2.2 Corrosion-Resistant Steels

AISI-304
AISI-321
AISI-347
AM-350
AM-355
A-286

Stainless steels with over 1/2 percent of molybdenum should not be used over 160 F; below 160 F, more than 1/2 percent molybdenum can be used.

4.2.3 Other Alloys and Metals

Inconel
Inconel-X
Titanium 6Al-4V
Stellite No. 21
Chromeplating, (only if of good quality)

4.2.4 Nonmetallic Materials

Kel-F Teflon Teflon 100-X	Test results show only small decrease in tensile properties after 7 weeks exposure (Ref.5).
Polyethylene	High Density Type
Nylon	
Butyl Rubber	Stillman Rubber No.613-75 and Enjay Co. No. 6297

Graphite
D. C. 11
Sinclair L-743 (MIL-L-25335)
Braided Asbestos impregnated with Teflon (for pump packing)
Monsanto, -Arochlor-1254
Glass lining (as Pfaudler, or A. O. Smith)

4.3 Materials Suitable for Limited Service

Iron and carbon steel can be used for limited service when properly descaled and cleaned. However, the use of iron and carbon steel is NOT recommended because the introduction of air and moisture will cause oxidation and rusting, and will result in the decomposition of hydrazine.

4.4 Unsuitable Materials

The following materials should be avoided in hydrazine systems because of decomposition, corrosion, or contamination:

4.4.1 Metals:

Brass, all types
Bronze, all types
Lead
Zinc
Cadmium
Magnesium

Molybdenum over 0.5 percent in alloys (over 160 F)

Silver
17-4-PH
Nickel
Hastelloy alloys
Gold
Stellite alloys other than No. 21
Monel alloys
Copper
Cobalt alloys
Steels - 4130 and 4340
Aluminums - 40-E and 7075

4.4.2 Nonmetallic

Mylar	Dissolves
Viton A	Becomes brittle and flakes
LS-53	Disintegrates
Neoprene	Swells and blisters
Buna-N	Swells, softens, and becomes gummy after extended exposure
Saran	
PVC (Tygon)	
PVA	
PT 201-G Coating	Blisters, particularly in N_2H_4 vapor
Kel-F 300	
Kel-F 5500 Elastomer (Compound 89)	Blisters and becomes sticky
Fluoro-Lube	Corrodes both aluminum and stainless steel in presence of N_2H_4
MIL-L-6086	Precipitation even in 0.1 percent N_2H_4 concentrations; forms wax with higher N_2H_4 concentrations

4.5 References

4.5.1 "Mathieson Anhydrous Hydrazine (N_2H_4)," published by Olin Mathieson Chemical Corporation.

4.5.2 "Literature Survey on the Use of Hydrazine as a Rocket Fuel," Navy Department of the Bureau of Aeronautics, Research Technical Memorandum No. 62, RTM-62, by Aerojet Engineering Corporation, 13 April 1950.

4.5.3 "Research and Developmen[illegible] in the Basic Design of Storable High-Energy Propellant Systems and Components," (Hydrazine and Nitrogen Tetroxide), Quarterly Progress Report No. 1, AFFTC-TR-59-41, Bell Aircraft Corp., December 1959.

4.5.4 Ibid, Quarterly Progress Report No. 2, AFFTC-TR-60-5, Bell Aircraft Corp., 15 January 1960.

4.5.5 "Investigation of Liquid Rocket Propellants," by M. R. Hull and others, Aerojet Engineering Corporation, January 25, 1950, CONFIDENTIAL.

4.5.6 "Investigation of Liquid Rocket Propellants," by C. L. Randolph and others, Aerojet Engineering Corp., January 1951, CONFIDENTIAL.

4.5.7 Scott, Burns, and Lewis: "Explosive Properties of Hydrazine," Report 14460, U.S. BurMines, Department of the Interior, May 1949.

4.5.8 "Storable Liquid Propellants," Report No. LRP-198, (October 1960), Aerojet-General Corporation.

4.5.9 "Rapid Identification (Spot Testing) of Some Metals and Alloys," published by International Nickel Co.

5.0 EQUIPMENT DESIGN AND SELECTION

5.1 General

The list of reference material included is a compilation of readily available data to facilitate the design and specification of systems handling hydrazine. Manufacturers listed herein are typical only for the type of product, and the list does not restrict the field to those mentioned, or eliminate those not mentioned.

In the design of systems for use with reactive materials, special care must be taken in the selection of pressure relief and vent systems (Ref. 5.12.24). All systems should include suitable filters to filter the hydrazine and purge blanket, or pressurizing gas before it enters the systems. Piping and vessel systems should be electrically bonded and grounded so that the maximum resistance from flange to flange shall not exceed ten milliohms and the resistance from any part to ground shall not exceed 25 milliohms.

5.2 Vessels

All pressure vessels for propellant storage shall be designed and constructed in accordance with ASME Boiler and Pressure Vessel Code, Sect. VIII, latest edition, as a minimum. Also, all pressure vessels shall be designed and constructed to satisfy applicable local and state codes for vessels.

All other vessels shall be designed and constructed in accordance with good engineering practice for the pressure and service in which they are to be used.

A minimum safety factor 4 for vessel and vessel support material strength shall be maintained in all designs. Due allowance shall be made for temperature, corrosion, and local seismic conditions. Riveted and bolted vessels are prohibited.

5.3 Piping Systems

5.3.1 General

Information of a general and specific nature relating to pipe, pipe material, and piping installation is extensively covered in Ref. 5.12.4, 5.12.5, and 5.12.6.

5.3.2 System Design

All piping used in the storage, venting, and transfer of propellants shall be designed in accordance with Sect. 3 and 6 of Ref. 5.12.3. Allowable tensile stresses for pipe materials are listed in Table 12 of Ref. 5.12.3. Material specifications for pipe, fittings, valves, flanges, tubing, and boltings are listed in Table 8 of Ref. 5.12.3.

In design of hydrazine systems, care should be taken to provide drainage and avoid traps so that system drainage is complete. Where trap conditions are unavoidable, drain fittings or valves should be provided.

The accompanying flow chart (Fig. 5) for hydrazine in Schedule 40 piping are based upon graphical solution of:

$$P = \frac{1.35 \, f \, S \, Q^2}{d^5}$$

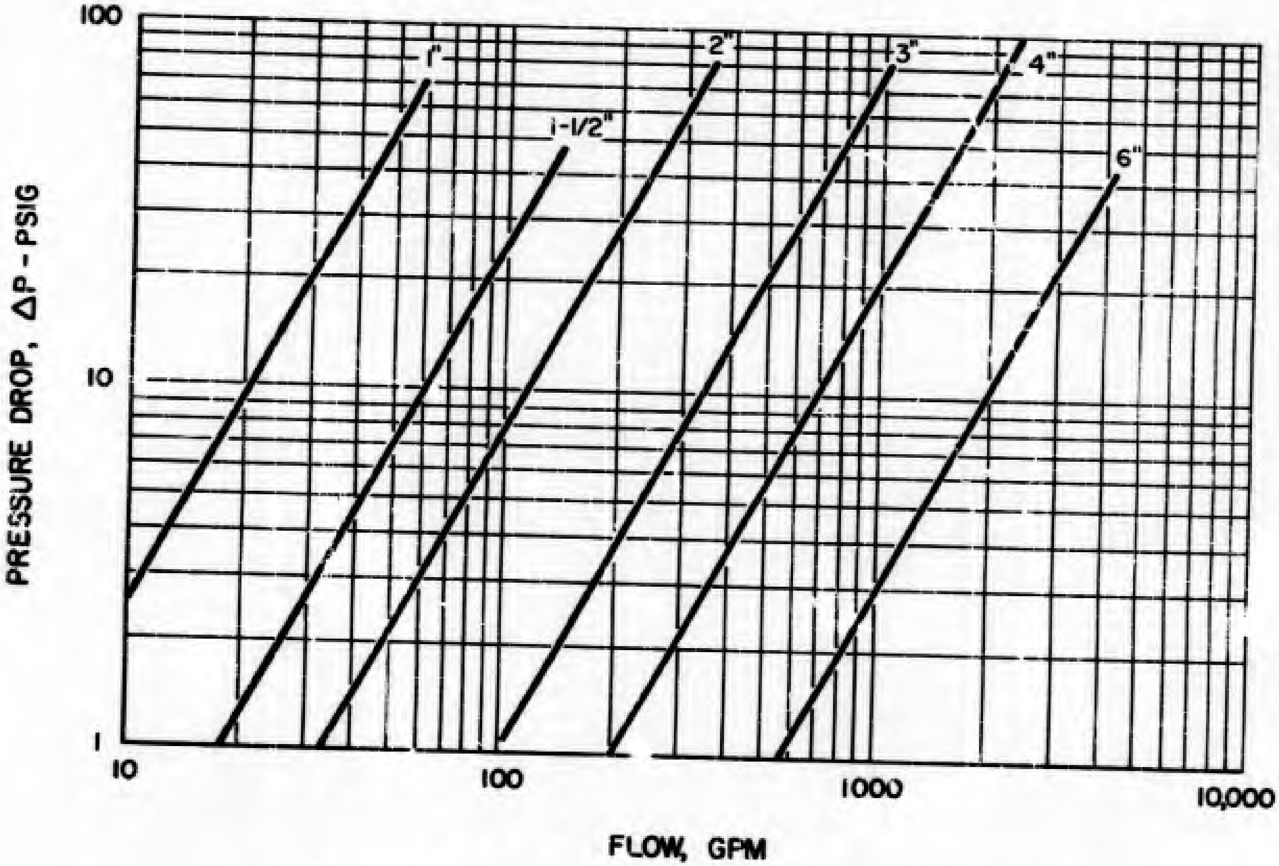

Figure 5. Flow Chart for Hydrazine in Schedule 40 Piping at 77 F

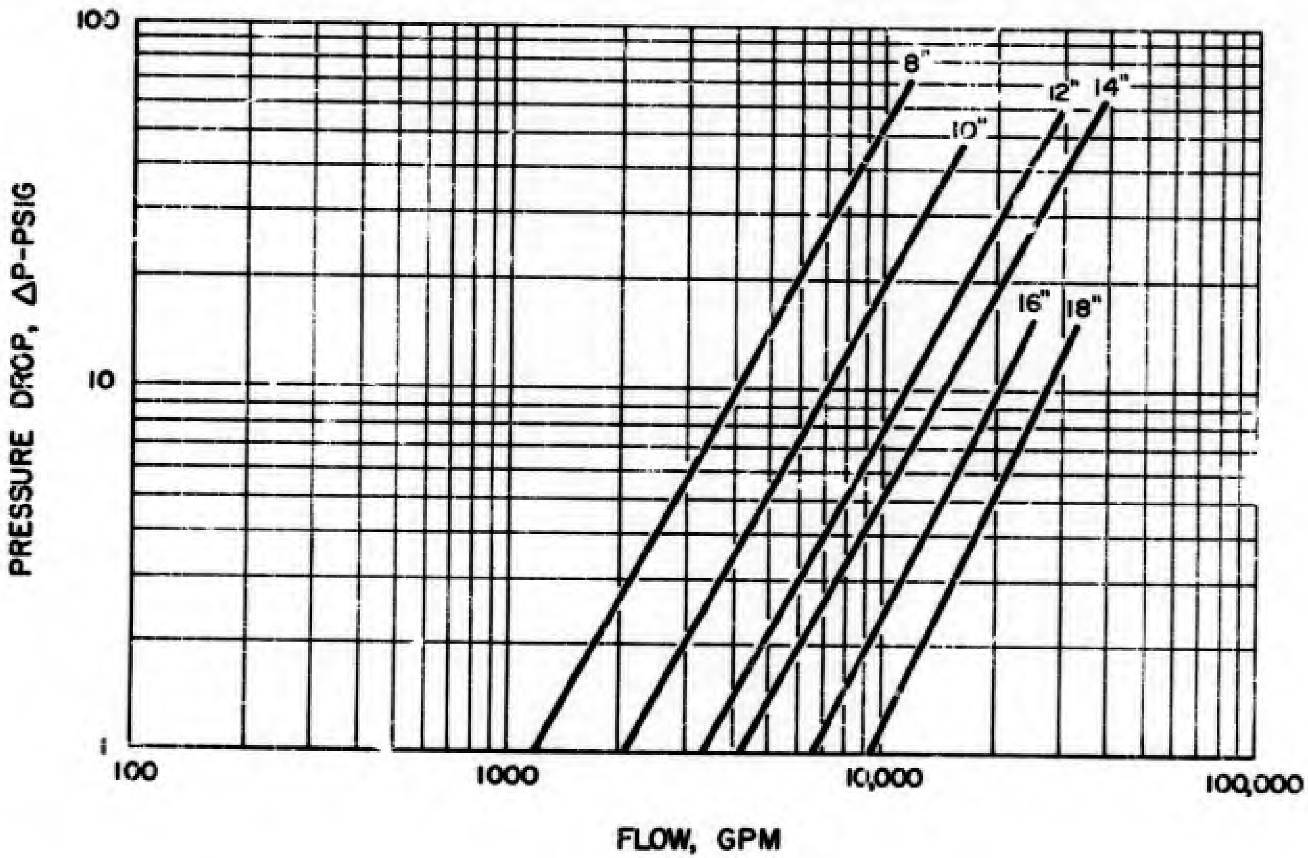

Figure 5 (Continued)

where:

P = pressure drop in lb/in.^{2} per 100 ft of pipe

f = friction factor (Fanning)

S = specific gravity

Q = flowrate, gal/min

d = internal pipe diameter, inch

5.3.3 Pipe and Fittings

Pipe and welding fittings are normally manufactured according to standard thickness and weight, as proposed by the American Standards Association. Adherence to these standards reduces unnecessary duplication in the manufacture of pipe and facilitates purchases in small lots. The standard schedules for stainless steel is given in Ref. 5.12.19. The schedule number of a pipe approximates the value 1000 x P/S to the nearest standard schedule number where P is the internal pressure and S is the allowable tensile stress of the pipe material, in accordance with Table 12 of Ref. 5.12.3. The standard schedule numbers for pipe manufactured from alloys other than stainless steels are, 40, 60, 80, 100, 120, 140, and 160. The standard schedules for stainless-steel pipe are 5S, 10S, 40S, and 80S. Other thicknesses in stainless-steel pipe are available on special order. Therefore, the nearest higher standard schedule to the required wall thickness should be used.

Pipe wall thicknesses shall be determined by the formula given in Ref. 5.12.3, Sect. 2, Chapt. 4, Para. 214 (-3).

$$t_m = \frac{P\,D}{2S + 0.8P} \qquad (1)$$

where

P = maximum allowable operating pressure, psig

D = outside diameter, inches

t_m = minimum pipe wall thickness, inches

S = maximum allowable hoop stress, pounds/sq in.

C = allowance for mechanical strength, threading, and/or corrosion, inches

NOTE: Allowance should be made for temperature, as required.

A manufacturer's tolerance of 12.5 percent is to be considered when using the formula, which can be obtained by multiplying the value of t x 0.875. As the ASA Code points out, this method of solution is applicable to the so-called thin-walled pipe in which the pipe wall thickness, t, minus C (corrosion allowance in inches plus thread depth or groove depth) is less than 1/6 times the outside diameter. Where this ratio is exceeded, Para. 324, Ref. 5.12.3 recommends the use of the Lame Formula plus the value C for determination of pipe wall thickness. The Lame Formula is:

$$\frac{D^2 + d^2}{D^2 - d^2} = \frac{S}{P} \qquad (2)$$

where

D = outside diameter, inches

S = allowable tensile stress (per Table 12 of Ref. 5.12.3

P = design pressure, psi

A convenient form of the Lame Formula is given in Para. UA-2 of Ref. 5.12.1 and is recommended for use with thick-walled pipe. The use of the Lame Formula for thick-walled pipe results in a somewhat thinner wall than that obtained by the use of the previously mentioned formula.

5.3.4 Pipe Hangers and Supports

Pipe supports, hangers, anchors, guides, and braces should be designed to prevent excessive stresses, deflection, and motion in operation of the system, or too large a variation in loading with changes in temperature, and to guard against shock or resonance with imposed vibration and/or critical flow conditions. Design and selection of the pipe supports shall be in full accordance with Ref. 5.12.3, Sect. 6, Chapt. I. Additional information is included in Ref. 5.12.4, 5.12.5, 5.12.6, 5.12.10, 5.12.14, 5.12.23, and 5.12.27.

5.3.5 Standard Flanges for Pipe

Tables are found in Ref. 5.12.1, 5.12.3, 5.12.4, 5.12.21, 5.12.22, and 5.12.23, showing the allowable working pressure ratings of pipe flanges at various operating temperatures.

ASA-B-16.5 flanges consist of seven pressure classes, each identified by the primary operating pressure: 150 pounds, 300 pounds, 400 pounds, 600 pounds, 900 pounds, 1500 pounds, and 2500 pounds. These nominal pressure ratings are the ratings at an elevated temperature below which operating pressures higher than rated are allowable. Each pressure class contains a range of sizes and types. Within the same class, the allowable working pressure varies with the material and the operating temperature. Flange bolting materials should be in accordance with Ref. 5.12.3, Sect. 3, Para. 209.

Flanged connections should be utilized as follows:

1. All flange connections shall conform to ASA specifications (Ref. 5.12.3, Table 8)
2. For pressures below 300 psi (150 lb ASA), raised faced flanges with serrated-finish gasket faces shall be used
3. For pressures above 300 psi (to 2500 lb ASA), either tongue and groove or RTJ flanges shall be used

5.3.6 <u>Expansion Joints and Flex Joints</u>

Pipeline expansion joints and flex joints for hydrazine service shall be limited to the packless, bellows type. Where flow conditions permit, liners should not be used in the joints because they make proper cleaning difficult. Where it is possible, it is always more desirable to design a piping system with the inherent flexibility of the pipe itself in the form of loops or bends to offset excessive thermal movement and resulting high stresses. Where this is impossible, bellows-type joints, designed in accordance with good engineering practice (Ref. 5.12.15 and 5.12.16) are recommended. Other data are included in Ref. 5.12.5 and 5.12.12. Particular attention should be taken to determine motions and stresses of flex joints and to avoid and eliminate harmful stress conditions which can cause premature failure. Of prime concern is the absolute elimination of torsional stresses from joints. Flex joints should be restrained in the linear direction to avoid stressing the piping. For flexing motion in one plane, pinned and gimbaled joints are available.

5.4 Stainless-Steel Tubing and Fittings

All systems specifying stainless-steel tubing shall conform to MIL-T-8808A or MIL-T-8606A for Type 321 or Type 347 stainless, or to MIL-T-8504 for Type 304 stainless. Fittings shall conform to AN or MS Standards for flared-tube fittings. Various reports on stainless steel tubing and fitting applications point out the inadequacies of commercial tubing (ASTM A213, ASTM A269) and commercial flared-tube fittings. Broad tolerances in surface finish, dimensions, and other specifications prohibit their use for fabricating consistent leak-tight joints.

Tube (AND) connections have been used with success, but are available only in sizes to 2 inches.

5.5 Valves

5.5.1 General

The selection of valves for hydrazine service imposes certain design requirements, but generally they are not as stringent or critical as for many other propellants. Of primary consideration is materials compatibility; generally, any valve design acceptable for use with other more common liquids may be used successfully with hydrazine if compatible materials are used. Leakage cannot be tolerated in valve selection for hydrazine use, therefore "plastic-seated" valves are recommended.

Valves used with hydrazine should be thoroughly cleaned, inspected, serviced, proof-pressure tested, and leak-tested prior to installation and use. Other factors in valve selection, particularly for propellant transfer use are:

1. Action and response
2. Pressure loss (C_v factor)
3. Migration of sealing material

Fast and positive valve action is definitely required for transfer use with high-energy propellants. The C_v factor is a measure of the pressure drop of the valve and is defined as the number of gallons of water per minute which will flow through a certain valve with a pressure differential of 1 psig (Ref. 25).

Particle migration is a problem whenever valve parts rub, or turn, or wedge on plastic sealing materials such as Teflon, Kel-F, Nylon, and polyethylene (Ref. 5.12.26). Migration can cause considerable problems in seal life, plugging of minute holes in orifices, and fouling of close tolerance fits. Migration is a particular problem in ball valves and soft-seated gate valves.

The following valve types have been satisfactorily employed in hydrazine service, and their use (or equivalent) is recommended.

5.5.2 Needle Valves

Needle valves used for bleed and purge should meet the same requirements as shutoff valves.

Valves with O-ring or composition packing should be avoided. Teflon chevron packing is recommended for dynamic seals. Avoid lubricated valves and valves with lubricated surfaces exposed to the fluid. All valve materials should conform to those materials as specified in Sect. 4, and all valves used should be capable of bubble-tight sealing.

5.5.3 Shutoff Valves

5.5.3.1 General

For shutoff and transfer operations, any of the Globe, gate, butterfly, or ball types may be used. Of these four types, the Globe and ball designs offer the optimum in service life and tight shutoff, with the Globe type being preferred.

5.5.3.2 Globe Valves

Split-body type globe, or angle globe valve with Teflon seat and chevron packing, such as manufactured by Annin Valve Company, Pacific Valve Company, or equivalent, are recommended for general shutoff and transfer service. These valves are available in all-stainless steel construction with Teflon trim, in pressures up to 5000 psi, sizes up to 8 inches, and are supplied with any desired mode of valve operation, i.e., manual, air-operated, etc.

5.5.3.3 Ball Valves

In the rotary ball valve design, the user gains the advantage of full flow with minimum pressure drop. Tight shutoff is achieved with pliable Teflon or Kel-F seat materials.

Valves of this type are manufactured by Jamesbury Company, Hydromatics Company, Worcester et al. Their use is generally restricted to 150-psi and 300-psi ASA pressure ranges and they are available in sizes up to 8 inches (Ref. 5.12.26).

5.5.3.4 Gate and Butterfly Valves

Gate and butterfly valves should generally be avoided, as these designs are not as durable, or else incorporate undesirable features such as uncertain sealing characteristics.

5.5.4 Check Valves

As with shutoff valves, a variety of designs exist which may be used in hydrazine service, depending upon system requirements. For sizes up to 2 inches, the aircraft-type, or in-line poppet check valve of stainless-steel construction with Teflon or Kel-F soft seat is recommended. Valves manufactured by Southwestern, Lanagan, or equivalent have been used successfully. For systems above 2 inches pipe size, any of the high quality industrial type valves of the swing check, poppet, or ball check designs are acceptable when constructed of compatible metals and seat materials.

5.5.5 Valve Connections

Valve end connections are divided into four general categories, i.e., (1) AND connections; (2) ASA flanged connections; (3) Welded-type connections; (4) NPT threaded connections. NPT threaded connections should be avoided, and because of servicing requirements of valving in place, Type (3) should be avoided.

5.6 Relief Devices

Any high-quality relief valve with good relief-reseat characteristics and bubble-tight shutoff upon reseat may be used. Valves should be of stainless-steel construction with Teflon seat. Valves made by Republic, Crosby, Powel, Anderson-Greenwood, or equivalent are recommended for this service (Ref. 5.12.24).

As an alternate relief device, rupture disks (burst disks) (frangible disks) are recommended. Disks are available in a wide variety of sizes, materials, and ratings. Disks require special safety-head holders or flanges. Since the hydrazine systems will be operated at all times under slight positive pressure of an inert gas, the use of vacuum support with rupture disks will not be required.

Relief devices should be rated and selected to burst at not more than 100 percent for primary relief devices, and 105 percent for secondary relief devices of vessel or system maximum working pressure. The relief devices must be sized to prevent the pressure from rising 10 percent above the maximum working pressure.

5.7 Regulators

Regulators are primarily used to supply regulated nitrogen gas for transfer, blanketing, purge, and control systems. The selection of regulators for service in hydrazine storage facilities depends upon their use. If a regulator is in a system which cannot be internally contaminated with hydrazine, no special requirements are necessary. Where contamination is a possibility, the regulator material must conform to those specified in Section 4. Because regulator diaphragm material is not compatible with hydrazine, the diaphragm can be protected by covering the exposed surface with a thin sheet of Teflon or Kel-F. Regulators manufactured by Grove, Victor, Hoke, or equivalent have been used successfully.

5.8 Pumps

5.8.1 General

The pumps that may be utilized for hydrazine service are primarily of the centrifugal or rotary type. Reciprocating pumps have not been considered for use in this service because of adaptability of other types of pumps to this service, maintenance problems, etc.

5.8.2 Centrifugal Pumps

Centrifugal pumps are among the most popular types because of their simplicity, low cost, and ability to operate under a wide variety of conditions. The centrifugal type is the most widely used pump for large volumes at moderate heads, for these reasons:

1. The output pressure and flow are virtually nonpulsating
2. The discharge can be throttled without the pump building up excessive pressure

3. It can operate at speeds that are standard for electric motors and turbines
4. By multistaging, it is adaptable for operation under practically any head
5. It can handle the liquid over a wide range of temperature
6. Ease of maintenance, service, and cleaning

However, they are limited in the respect that they require minimum absolute pressures on the intake suction, and they require priming whenever the fluid is drained from the casing.

Self-priming pumps are available in suitable materials. It should be noted that turbine-type pumps have many of the advantages of the centrifugal types and can produce much higher heads in the smaller sizes. Shafts and impellers for centrifugal pumps should be precision-balanced, both statically and dynamically, to assure maximum life of packing and seals, with minimum maintenance.

5.8.3 Rotary Pumps

The rotary pump combines the smooth discharge characteristics of the centrifugal type with the positive displacement feature of the reciprocating type. The flow from such a pump is virtually constant. The gear type of the rotary pump is the most widely used. This consists of two meshed gears placed in a close-fitting housing or case; one is the driving gear while the other is the idler. The Viking gear pump has become widely used for hydrazine service. This style pump can utilize a mechanical seal in lieu of packing and subsequently has proven to be quite satisfactory. Internal clearances and materials in rotary pumps must be closely checked as hydrazine has poor lubricating properties and pumps can be damaged by galling.

5.8.4 Drum Pumps

For transfer of smaller capacities from ICC Spec. 5C and 5G stainless-steel drums, a "drum" pump which attaches directly to the drum bung may be used. The air-driven reciprocating type, such as those manufactured by Grace or equivalent, are quite satisfactory for this service.

5.9 Filters

Filters have an important role in hydrazine storage and transfer systems in maintaining propellant and inert gas cleanliness. Filters should be selected with woven wire mesh elements fabricated of appropriate and compatible materials. The sintered-microsphere-type elements should be avoided due to difficulty in cleaning, and also since the microspheres become loosened in repeated cleaning operations and disintegrate. Pleated-type elements, properly supported, are preferred because they provide a smaller filter case for the same filter area. The filters should be selected and located for easy and repeated opening and cleaning. The filter elements and case should be capable of supporting the full applied upstream pressure without damage, as this condition can occur with a plugged filter. Filters should be sized, rated, and selected for low pressure drop at the rated flows; 10-psig differential pressure is the recommended maximum differential across a clean set of elements. The largest pore size recommended for use in liquid propellant operation is 20 microns nominal. Since the wires of the filter mesh are very fine, and thus subject to damage and corrosion, ample spares should be provided in the initial procurement effort.

5.10 Air Pollution Monitoring

For use in monitoring air pollution in the vicinity of storage and handling facilities using hydrazine, a system can be installed to sample the air and detect and record air pollution. Commercial-type detectors are available for monitoring air for many and varied pollutants. It should be realized that because of fine sensitivity, some instruments may give erroneous readings due to other air pollutants such as solvent vapors. For field use in detecting leaks, spot checking, and checking decontamination, small portable units are available. The fixed type of monitor system should be installed with an alarm system.

5.11 Level Gages

Liquid level gages for propellant storage tanks must be selected of compatible materials and preferably of the same alloy as the tank and piping. If external tank sight gages are used, the gage valves should incorporate ball check valves for automatic liquid and vapor flow shutoff in case of glass breakage. The glass should be protected by a durable and sturdy guard. Suitable liquid level gages are manufactured in appropriate materials by Powel Valve Co., Jerguson, and Ernst Cage Glass & Water Column Co.

5.12 <u>References</u>

5.12.1 ASME Boiler and Pressure Vessel Code, Section VIII, Rules for Construction of Unfired Pressure Vessels, latest edition.

5.12.2 Unfired Pressure Vessel Safety Orders, issued by the State of California, Dept. of Industrial Relations, Div. of Industrial Safety.

5.12.3 American Standard Code for Pressure Piping ASA B31.1, 1955 edition.

5.12.4 Piping Handbook by Sabin Crocker (McGraw-Hill).

5.12.5 Design of Piping Systems by M. W. Kellog Co. (Wiley).

5.12.6 Industrial Piping by Charles T. Littleton (McGraw-Hill).

5.12.7 Tube Turns Bulletin TT770.

5.12.8 Tube Turns Bulletin TT726.

5.12.9 Tube Turns Bulletin TT640.

5.12.10 Piping Design and Engineering by the Grinnell Co.

5.12.11 Flow of Fluids through Valves, Fittings, and Pipe. Technical Paper No. 411 by the Crane Co.

5.12.12 Expansion Joint Standards by George P. Byrne, Jr., of the Expansion Joint Manufacturers Association.

5.12.13 Requirements of the American Petroleum Institute and the American Standards Association, including end connections and face-to-face dimensions.

5.12.14 Carpenter and Patterson, Inc., Cambridge, Mass.

5.12.15 Fabrication of USS Stainless Steel-United States Steel Corp.

5.12.16 Stainless Steel Fabrication, Allegheny Ludlum, Pittsburgh, Pa.

5.12.17 Stainless Steel Fittings Catalog, Ladish Co., Cudahy, Wisc.

5.12.18 Stainless Steel Fittings Catalog, Tube Turns.

5.12.19 American Standard for Stainless Steel Pipe ASA B36.19, latest revision.

5.12.20 American Standard for Pressure-Temperature Ratings of Standard Steel Pipe Flanges ASA B16.5, latest revision.

5.12.21 Ladish Catalog No. 55.

5.12.22 Tube Turns Catalog No. 311.

5.12.23 Crane Co. Catalog No. 53.

5.12.24 "How to Design A Pressure Relief System," by J. Connison, Chem. Eng., 25 July 1960.

5.12.25 Pacific Valve Co. Technical Paper #1060-2.

5.12.26 Pacific Valve Co. Technical Report #1060-3.

5.12.27 Grinnell Co. Catalog on Pipe Hangers and Supports.

6.0 SYSTEM FABRICATION

6.1 General

Hydrazine storage and transfer systems are similar to those employed for handling ordinary fluids, except for materials of construction. Pump motors, solenoid valves, electrical switchgear, and other electrical equipment in the hydrazine transfer and storage systems should be selected and installed in accordance with the requirements of the National Electric Code, Article 500, Class 1, Division 2. All seals and joints in the propellant system should be periodically and frequently inspected for leaks and damage.

In the layout, placement, and arrangement of operating systems and units, ample spacing should be provided for proper maintenance clearances and adequate ventilation. In many cases, the removal, replacement, and servicing of valves, pumps, piping sections, instrumentation, and other equipment must be done by workers in protective clothing and wearing respiratory equipment. Ample room and access must be provided for use of tools and for easy movement of equipment. Where possible, equipment, valves, and lines should be located so that maintenance and service work can be accomplished from a position above the piping level in order to prevent propellant drips and leaks from falling on personnel.

6.2 Welding

6.2.1 General

The standards for welding pipe shall conform to Chapt. 4 of Ref. .6 1. Pipe fittings should be procured from reputable sources who permanently mark their fittings as to: (1) manufacturer, (2) size and schedule of pipe, and (3) material and heat code. The fittings should be of the butt-welded type to facilitate system cleaning and purging operations. A typical set of standards for the acceptance of pipe welds is presented in Appendix 11.2.

The identity of each material used in the fabrication of propellant systems must be ensured. Test kits are available for the identification of metals in the field (Ref. 6.6.2).

6.2.2 Carbon Steel

Carbon steel piping and components are not recommended for service in hydrazine.

6.2.3 Stainless Steel

Fusion welding of stainless-steel pipe and fittings should be started with a root pass using the inert-gas-shielded tungsten arc method; helium or argon can be used as the inert gas. Subsequent passes may be made by the shielded metal-electrode method or by the inert-gas-shielded tungsten arc method. An inert gas (argon preferred) back purge should be maintained during the welding of stainless-steel pipe and fittings until the weld area metal temperature falls below 400 F. Shielded electrodes shall conform to MIL-E-6844 and welding rods to MIL-R-5031. Additional information on the welding of stainless-steel pipes and fittings can be found in Ref. 6.6.1, 6.6.3, 6.6.4, 6.6.5, 6.6.6, 6.6.7, and 6.6.8.

6.2.4 Aluminum

Since certain aluminum alloys can be used as pipe material for service in hydrazine, some discussion on the welding of this material is included. Fusion welding of aluminum pipe and fittings can be accomplished by the inert-gas-shielded tungsten arc method or by the shielded metal-electrode method. These welding methods require a back purge of inert gas. Detailed information on the welding of aluminum and aluminum alloys can be found in publications of the leading aluminum manufacturers (Kaiser, Reynolds, Alcoa, etc.).

6.2.5 Welding of Other Pipe Materials

The welding of other pipe materials compatible with the subject propellant can be found in Ref. 6.6.3 and 6.6.4.

6.3 Brazing and Soldering

Brazing and soldering techniques are not recommended for application in hydrazine systems. The joints produced by these methods are usually incompatible with the propellant.

6.4 Mechanical Joints

6.4.1 General

The advantages of a relatively leak-free all-welded transfer system are obvious. From a practical standpoint, however, some type of joint, whether flanged or otherwise, is required to facilitate maintenance and to provide adequate system flexibility.

Small valves and components should be selected with AN flared-type connections. Large valve and components should be selected with flanged connections. Instrumentation connections should be of the AN type, and can be provided by welding boss fittings on large pipe lines or by installing tee fittings on small lines.

6.4.2 <u>Threaded Pipe Joints</u>

Threaded pipe joints shall be avoided since these joints are a potential leakage source. In addition, localized corrosion may originate in this type of joint.

6.4.3 <u>Flanged Pipe Joints</u>

Flanged pipe joints are recommended whenever it is not practical to use welded joints. The flanges shall conform to ASA standards (Ref. 6.6.1, 6.6.9, and 6.6.10) for the welding neck type. Small tongue and groove, or raised-face flanges are preferred since most valves and pipe line components used in transfer systems can be furnished with these facings. A 1/8-inch-thick full-face gasket of appropriate material is recommended for sealing the flanged joints. To assure minimum distortion in welding these flanges to piping, a heavy backup plate or mating flange must be installed during welding operations.

6.4.4 <u>Tube Connections</u>

Flared tube connections can be used in hydrazine systems. This type of joint is particularly suitable for instrumentation sensing line connections.

6.5 Inspection

6.5.1 General

In the construction, installation, and modification of hydrazine systems, inspection is important to assure quality of materials, adherance to design specifications, and proper fabrication techniques.

Before installation, each piece of equipment such as pumps, flex joints, valves, filters, etc., shall be inspected and tested for:

1. Cleanliness
2. Proper lubricants (if allowable)
3. Leakage, internal and external
4. Pressure proof test
5. Sealant and gasket materials
6. Proper operation
7. Freedom from defects
8. Adherence to applicable specification: type, size, rating, dimensions, etc.

Piping and tubing sections shall be inspected and tested for:

1. Conformance to design specifications and building codes
2. Identity and quality of materials of construction
3. Adequacy of supports; freedom from "cold spring"

4. Cleanliness

5. Proper fabrication workmanship

6. Proof pressure and leak tests

7. Proper installation of flex joints

Electrical installations and equipment shall be inspected and tested for:

1. Conformance to design specifications and applicable codes

2. Adequate grounding

3. Insulation resistance

4. Circuitry continuity and proper termination

5. Workmanship and fabrication technique

6. Proper support of conduits and wiring

Instruments (flowmeters, gages, transducers, etc.) shall be shop tested, calibrated, and certified with due regard to using conditions, fluid density, operating range, material identity, repeatability, and sealing capability.

Roads, buildings, structures, etc., should be inspected for conformance to design specifications and building codes.

6.5.2 Radiographic Inspection

Items fabricated from standard pipe and fittings ordinarily have a sufficient factor of safety that radiographic inspection is not necessary. However, radiographic inspection may be required under the following conditions:

1. When noted on the governing drawing or specification; such is the case when it becomes necessary to obtain high weld efficiencies
2. When welds are visually suspicious; such as the case when the welder or the inspector doubts the soundness of the weld
3. When items are fabricated from nonstandard piping or fittings

Critical areas such as primary structures and anchor weldments, whose failure would result in installation or anchor collapse, shall be thoroughly analyzed by the designer and radiographic inspection specified, if required.

Radiographic inspection shall be specified only when it is beneficial. This type of inspection is not applicable to all weld types and is a relatively costly process. Properly designed piping systems, welded by a certified welder and visually inspected by a qualified inspector, normally do not require radiographic inspection.

6.6 <u>References</u>

6.6.1 "American Standard Code for Pressure Piping, ASA B31.1," latest edition.

6.6.2 "Rapid Identification (Spot Testing) of Some Metals and Alloys," International Nickel Company.

6.6.3 Commercial Publications by Carpenter and Patterson, Inc., Cambridge, Mass.

6.6.4 "Welding Handbook," American Welding Society.

6.6.5 "Fabrication of USS Stainless Steel," United States Steel Corp.

6.6.6 "Stainless Steel Fabrication," Allegheny-Ludlum Corp., Pittsburgh, Pa.

6.6.7 Stainless Steel Fittings Catalog, Ladish Co., Cudahy, Wisc.

6.6.8 Stainless Steel Fittings Catalog, Tube Turns.

6.6.9 "American Standard for Pressure-Temperature Ratings of Standard Steel Piping Flanges, ASA B16.5," latest edition.

6.6.10 "Piping Handbook," by Sabin Crocker, McGraw Hill.

7.0 HYDROSTATIC AND/OR PNEUMATIC TESTS

7.1 <u>Storage Vessels</u>

Vessels certified by an ASME inspector and/or state safety order code inspector need not be tested. Vessels that are exempt from or vary from the ASME code shall be tested in conformance with ASME code requirements. Vessels that have been damaged because of fire, fragmentation, etc., or that have been reworked or repaired, must be re-inspected and recertified for use.

7.1.1 <u>Hydrostatic Test</u>

The hydrostatic test shall in no case be to less than 1-1/2 times the maximum allowable working pressure which is to be stamped on the vessel. No upper limit is set on the hydrostat; however, if the pressure is allowed to exceed (intentionally or accidentally) 1-1/2 times the maximum allowable pressure to the extent that the vessel is distorted, the inspector will reserve the right to reject the vessel. The test pressure shall be held for a sufficient time to permit an inspection to be made of all joints and connections.

Vessels that require hammer tests shall be tested while the hydrostatic pressure is between 1-1/4 and 1-1/2 times the maximum pressure.

7.1.2 <u>Pneumatic Tests in Lieu of Hydrostatic Test</u>

Vessels and attached systems shall undergo pneumatic tests in lieu of hydrostatic test under the following conditions.

1. When the vessels and attached systems are so designed and/or supported that they cannot safely be filled with water

2. Those to be used in service where traces of the testing liquid cannot be tolerated

3. Those systems where the parts have been previously hydrostatically tested to 1-1/2 times the maximum working pressure of the vessel

The pneumatic test presssure shall be at least 1-1/4 times the maximum allowable pressure.

Welded vessels shall be hammer-tested prior to the pneumatic test.

<u>Caution</u>. All personnel shall be evacuated from the area until after a test has been conducted to a pressure of 1-1/4 times the maximum operating pressure and the pressure has been reduced to the maximum operating pressure or less for vessel inspection.

The test pressure in the vessel shall be increased gradually to not more than 1/2 the test pressure. Thereafter, the pressure shall be increased in increments of approximately 1/10 of the test pressure until test pressure has been reached. The pressure shall then be reduced to a value equal to the maximum allowable pressure and held for a sufficient time to allow inspection of the vessel. Failure, leakage, distress, or permanent distortion shall be sufficient cause for rejection.

7.2 Valves, Piping, and Fittings

7.2.1 Hydrostatic Test Before Installation

Every valve, filter, check valve, flex joint, etc., shall withstand an internal hydrostatic proof pressure for which the manufacturer guarantees it, without leakage, failure, or permanent deformation.

Each prefabricated or spooled pipe section, manifold, and special fitting shall be inspected and tested in accordance with Ref. 7.3.2, Section 3, Para. 322 and 323. In case of leakage, deformation, or failure, the piping shall be properly repaired and retested.

The hydrostatic test shall be conducted with either water or hydraulic oil as the test media. Only those components to be utilized in hydraulic oil or kerosene-type-fuel systems may be proof-tested with hydraulic oil.

7.2.2 Hydrostatic Test After Installation

After the system is installed and secured, it shall be pressure-tested in accordance with Ref. 7.3.2, Sect. 3, Para. 323. In case of leakage, damage, failure, or deformation, the piping shall be properly repaired and retested.

7.2.3 Pneumatic Test in Lieu of Hydrostatic Test

A pneumatic proof-test shall be conducted ONLY when water will damage parts or when the presence of minute amounts of water cannot be tolerated, and the configuration of the system prevents a guarantee of dryness.

The pneumatic proof test is allowable **ONLY AFTER** prior hydrostatic proof test of subassemblies and components to 1-1/2 times the maximum operating pressure. Test fluid should be clean, filtered, dry, hydrocarbon-free nitrogen gas or air.

The pressure shall be increased slowly to 1-1/2 times the maximum allowable operating pressure and be locked and held for five minutes. If the pressure gage indicates a drop in pressure, the pressure shall be relaxed, the cause of leakage or creep corrected, and the test repeated.

Caution. Personnel shall not enter the area until after a test has been conducted to a pressure of 1-1/2 times the maximum operating pressures or less, for inspection.

Failure, leakage, distress, or distortion (other than elastic distortion) shall be sufficient cause for rejection.

7.3 Applicable Codes and Specifications

7.3.1 ASME Boiler and Pressure Vessel Code, Section VIII, Rules for Construction of Unfired Pressure Vessels, latest edition.

7.3.2 American Standard Code for Pressure Piping ASA B31.1, latest edition.

8.0 CLEANING PROCEDURES

8.1 General

This section outlines the chemical cleaning procedures to be employed to remove oxides, scale, dirt, weld and heat-treat slag, oil, grease, and foreign material from storage facility equipment. Items previously cleaned and passivated per this section, and which have not been machined, welded, heated, or otherwise contaminated or oxidized, may be prepared for service by degreasing. Basically, items such as valves, pumps, actuators, etc., cannot be cleaned in the assembled state since solvents may damage nonmetallic parts, or residues may be trapped in inaccessible areas. Therefore, cleaning should be done immediately before assembly, or cleaned parts should be packaged to protect against recontamination until ready for assembly.

All cleaning, passivating, and rinse solutions should be applied by immersing, spraying, wiping, circulating, or other manner so that ALL surfaces to be cleaned will be completely wetted and flushed with the solutions. Any section of the item to be cleaned that can trap or retain any liquid should be drained or emptied between the applications of each different solution of chemical mixture. The item should be rinsed until it is chemically neutral between each operation. Do not allow metal surfaces to dry off between cleaning and passivation steps. The water used should be distilled, deionized, or clean tap water, filtered through a 40-micron nominal filter. Unless otherwise specified, all chemicals should be C.P. (chemically pure) grade or better.

8.2 Degreasing

8.2.1 Metal Parts

All metal parts should be degreased by cold-flushing with high-purity, low-stabilized trichloroethylene, vapor degreased with trichloroethylene which meets MIL-T-7003 Specification, or flushed with a mild alkaline soluiton (5 to 7 oz/gal) at 140 F to 160 F, such as Turco #4090 or equivalent. If used, the mild alkaline cleaner must be followed by a water rinse to remove all traces of cleansing compound.

Large parts, whose size or configuration prevent vapor degreasing or cold flushing in a spray booth, should be degreased by spraying or hand-wiping with high-purity, low-stabilized trichloroethylene or with a mild alkaline cleaning solution such as Turco #4090 or equivalent. Degreasing agents used for hand-wiping, brushing, or in a spray booth shall not be reused.

8.2.2 Nonmetal Parts

Nonmetallic and borded nonmetallic parts such as gaskets, O-rings, chevron rings, hoses, etc., should be degreased by immersion or scrubbing at 140 to 160 F with the mild alkaline solution (5 to 7 oz/gal) mentioned above, or equivalent, followed by rinsing with water. Teflon, polyethylene, Kel-F, or Viton, except when bonded to metal, may be cleaned with trichloroethylene. Items which have solvent or water remaining on their surface and are not to be further chemically cleaned, shall be dried.

8.3 Descaling or Cleaning

8.3.1 General

Newly fabricated or reworked parts which have scale from welding, heat-treatment, or impurities from casting or forging, should be descaled. Descaling solutions should not be used after finish-machining of precision surfaces without protection or on parts that do not have heavy oxide or foreign material buildups in the form of rust or scale. The contact time of the descaling solution and the item to be cleaned should be the minimum time necessary to clean the part or the maximum allowable time per this section, whichever is shorter.

Only plastic-coated or nonmetallic gaskets should be used with nitric-hydrofluoric descaling baths, to prevent excessive metal loss caused by electrolytic corrosion.

8.3.2 Stainless Steel

1. Etch for a minimum period, and not longer than sixty minutes, at room temperature (60 to [illegible] F) with a mixture of three to five percent technical grade hydrofluoric acid (by weight), fifteen to twenty percent technical grade nitric acid (by weight), and the remainder water.

2. Rinse with water to remove all traces of descaling solutions. Loosely adherent smut or flux may be removed by spraying with water or scrubbing with a stainless-steel or hemp brush. If the parts are to be <u>immediately</u> passivated after acid cleaning, they

need not be dried. The parts may be dried completely by purging with dry, hydrocarbon-free nitrogen or air, or in an oven at 140 to 150 F. The AISI 400 series, 303S, and 303SE shall be descaled by mechanical methods such as machining, abrasive tumbling, or grit blasting.

Parts descaled by acid pickling or mechanical methods should be passivated as indicated.

8.3.3 Aluminum and Aluminum Alloys

1. Clean with a chromic acid cleaner (5 to 7 oz or Turco Smut-Go or equivalent cleaner per gallon of water), at 100 F, until the surfaces are visibly clean and shiny.
2. Rinse with water to remove all traces of the acid solution.

8.4 Passivation

8.4.1 General

All corrosion-resistant steel, except nonwelded tubing assemblies, shall be passivated after descaling or final machining. All metals used should be cleaned and passivated before use and maintained in a clean, dry condition until installed.

Acid passivation of components with highly polished or lapped surfaces may be eliminated if the polished or lapped surfaces cannot be conveniently protected from the acid solution.

8.4.2 <u>Stainless Steel</u>

1. Immerse in a solution of 45 to 55 percent technical grade nitric acid (by weight) with the remainder water, at 60 to 80 F, for a minimum period of thirty minutes.

2. Rinse and flush thoroughly with water to remove all traces of the passivating solution.

3. Drain and dry by purging with dry, filtered, hydrocarbon-free nitrogen or air, or dry in an oven at 140 to 150 F.

The nitric acid passivation solution should be used for the AISI 300 and 400 series stainless steel. The protective film resulting from this passivation process will not normally be visible, but surfaces shall be uniform in appearance, free from scale, corrosion, pitting, and contaminants. Normal discoloration from welding will be permitted, provided no scale or rust is associated with the discoloration.

8.4.3 <u>Aluminum and Aluminum Alloys</u>

1. Passivate with a solution of 45 percent technical grade nitric acid (by weight) at room temperature for a minimum period of one hour.

2. Rinse and flush with water to remove all traces of nitric acid.

3. Drain and dry by purging with dry, filtered, hydrocarbon-free nitrogen or air, or dry in an oven at 140 to 150 F.

Machined aluminum barstock parts do not normally require descaling or passivating processes and can be prepared for service by degreasing. Welded, cast, or corroded parts will require descaling, cleaning, and passivating. Anodized aluminum parts shall not be descaled or passivated and should be prepared for service by degreasing.

8.5 Drying and Handling

8.5.1 Drying

Items which have solvent or water remaining on their surfaces and which are not to be further chemically cleaned should be dried by flushing with dry, hydrocarbon-free, filtered nitrogen gas or air, or by heating from 140 to 150 F.

8.5.2 Handling

Items that have been cleaned should be handled, stored, or packaged in a manner to prevent recontamination.

Immediately following cleaning and passivation, large valves, piping sections, vessels, flex joints, subassemblies, and other prefabricated items should be dried and have ends and openings capped, plugged, or flanged and sealed with clean compatible sealing material. Small valves and components should be purged with clean, dry gaseous nitrogen and wrapped and sealed in clean plastic bags. These components should be kept sealed until installation.

8.6 Inspection

8.6.1 General

All parts may be inspected for cleanliness by one or more of the following inspection techniques.

8.6.2 Visual Inspection

Parts should be inspected for rust, scale, dirt, chips, or grease, or other foreign material. The presence of such deposits will necessitate recleaning of the part. Light discolorations due to welding and passivation will be permitted providing no scale or rust is associated with the discoloration.

8.6.3 Water Break Test

The water break test is not a valid indication of cleanliness under the requirements and conditions of this section.

8.6.4 Soiling Test

After lightly wiping with a clean, lint-free, white cloth, no visible deposit shall occur on the cloth. Discoloration may occur with metals such as aluminum if the surface is rubbed hard enough to abrade the surface. Discoloration from this abrasion can be confused with dirt.

8.6.5 Ultraviolet Light (Black Light)

Inspection under ultraviolet light will cause some oils and grease to fluoresce. This procedure will not detect vegetable or animal-type oils and greases, RP-1, JP-5, NA2-20502 (liquid oxygen-safe), toluene, DC-11, Fluorolube, or MIL-0-5606. This test is not valid on service components without further identification of the fluorescent material, because some acceptable lubricants fluoresce.

8.7 <u>Material Reference</u>

8.7.1 Turco Smut-Go: Chromic acid-type cleaner furnished by the Turco Products Inc., 6135 South Central Avenue, Los Angeles, California.

8.7.2 Mild Alkaline Cleaner: Detergent-type cleaner similar to Turco #4090, furnished by Turco Products, Inc.

9.0 INSPECTION AND MAINTENANCE

9.1 General

A periodic inspection to determine the current and projected maintenance requirements should be made. This should take into consideration the frequency of use, reliability, environment, stresses, and other special conditions which may arise.

When performing inspection and maintenance operations, all safety precaution must be taken prior to entering vessels or systems used with hydrazine.

9.2 Inspection

9.2.1 Coded Vessels

All ASME Coded Vessels should be externally inspected by a qualified inspector at least once a year. An internal inspection shall be made whenever the head of the vessel is removed, or when the corrosion rate dictates.

9.2.2 Non-Coded Vessels

All non-coded vessels should be externally inspected by a qualified inspector at least once every six months. An internal inspection should be made whenever the head of the vessel is removed, or when the corrosion rate dictates. Based upon this inspection, hydrostatic tests may be required before use of the vessel is resumed.

9.2.3 ICC Vessels

All vessels that are ICC Coded, in addition to periodic inspections as described for other vessels (see above), shall be inspected and tested for conformance with ICC Code at least once every five years. All attendant systems should be periodically checked by a qualified inspector at least once every six months for leaks, potential failures, etc. Proof tests should be conducted to verify the safety of a system as deemed necessary by the inspector or responsible storage area personnel.

9.2.4 Vessel and Pipe Systems

Storage vessels and pipe systems should be checked at least once each six months for signs of settling, misalignment, tightness of connections, signs of leaks and corrosion. Settling can strain and rupture piping.

9.2.5 Safety Equipment

The water fog or spray system should be checked for flowrate, pattern and operation at least once each week.

All safety showers and eyebaths should be inspected and tested for flowrate, pattern, and operation on a bi-weekly basis or prior to any hydrazine handling operation.

Personnel protection equipment (clothing, respiratory equipment, etc.) should be checked for availability, and condition at least once a week or prior to any hydrazine handling operation.

9.2.6 Propellant Transfer Equipment

The equipment should be checked for proper operation on a bimonthly basis or by the operating personnel during each hydrazine handling operation.

9.3 Maintenance

9.3.1 Valves, and Pumps

Valves and pumps should be serviced when the operation of the item becomes erratic or a leak develops. Schedules can be established based upon expected service life for preventative maintenance.

9.3.2 Instrumentation Equipment

Instrumentation equipment should be serviced at least once each six months.

9.3.3 Filters

Filters should be serviced when the differential at rated flow conditions exceeds 15 psig, or as specified in the manufacturer's service instructions.

9.3.4 Relief Devices

Rupture discs (burst discs) should be replaced at least once each four months. Relief valves should be serviced at least once each six months.

9.3.5 Safety Equipment

Water fog or spray system, safety showers, and eye baths should be serviced at least once each four months. Personnel protection should be serviced at least once each month.

9.3.6 General Storage Area

The general storage area should be constantly maintained to good safety and housekeeping standards. Some of these maintenance operations are:

1. Removal of obstacles from roads, paths, and stairs.
2. Removal of combustible materials from the storage area
3. Prevention of equipment, piping, vessel, and etc. oxidation
4. Properly storing handling tools and equipment
5. Maintaining clean revetments, channels, basins, and sumps

10.0 REACTIVATION OF EXISTING FACILITIES

10.1 Design Evaluation

The design of existing facilities which are to be reactivated for use with hydrazine should be thoroughly evaluated with special attention to the following:

1. Allowable working pressures
2. Relief systems
3. Flowrates and pressure drops
4. Means of transfer
5. Systems configuration
6. Sealing characteristics
7. Supports, hangers, bracing and brackets
8. Maintenance clearances
9. Compatibility of materials of construction
10. Safety

10.2 Inspection of Usable Components

The components to be used should be dismantled and inspected for corrosion, deformaties, etc. If the components are unable to meet the standards established in Part I, they should be discarded. The identity of materials of construction can be verified by use of chemical spot tests ("Rapid Identification of Metals and Alloys," by International Nickel Co.)

10.3 Rework and/or Cleaning of Usable Components

Vessels, piping, valves, and other components to be used should be reworked and/or cleaned as follows:

1. Vessels shall be reworked and cleaned in accordance with sections 5.2.7.1 and 8.0.
2. Piping shall be reworked, cleaned and installed in accordance with sections 5.3.7.2 and 8.0.
3. Valves, flexjoints, pumps, check valves, etc. shall be reworked and cleaned in accordance with sections 4.0, 5.0, 7.2, and 8.0.

11.0 APPENDICES

11.1 Water Storage Capacity

The amount of water required for controlling hydrazine fires in the storage area can be determined by the following relation:

$$3.5\ V_1 + x\ V_2 + 10{,}000 = C$$

where

V_1 = capacity of largest single hydrazine storage tank, gal

V_2 = total hydrazine storage capacity, gal

x = a function, which can be expressed as:
1.8 for V_2 from 100 to 15,000 gal
1.7 for V_2 from 15,000 to 50,000 gal
1.6 for V_2 above 50,000 gal

C = water storage capacity required for fire control, gal

Satisfactory storage tank cooling can be obtained by applying water at a rate of 0.25 gpm per sq ft of external tank surface.

11.2 Acceptance Standards for Welds

A typical set of acceptance standards for welds is as follows:

1. Cracks of any nature, whether crater, underbead, transverse, longitudinal or parent metal will be rejected.

2. Crater cracks which are determined to be only surface defects may be removed by machining or grinding. They need not be rewelded provided buildup is not less than 10 percent nor more than 30 percent of the metal thickness, nor if drop-through is not less than flush nor more than 30 percent of the metal thickness.

3. Normally acceptable defects occurring in conjunction with or adjacent to cracks will be rejected for a distance of 2 inches each way from the crack.

4. Butt joints shall have 100 percent penetration throughout 100 percent of the linear length of the weld.

5. Any lack of fusion will not be accepted.

6. Undercut, excessive drop-through and excessive roughness shall be cause for rejection. Fold in drop-throughs will be accepted if they are not greater in depth than 10 percent of the thickness of the parent metal.

7. Porosity or inclusions occurring in the weld metal, exclusive of the weld reinforcements in which any radiographic image is darker than the parent metal or larger in its greatest dimension than 15 percent of the parent metal thickness will be rejected.

8. Porosity and inclusions in the weld reinforcement will be acceptable, provided they do not extend through the surface of the reinforcements, and provided they do not result in an objectionable stress riser.

9. Porosity and inclusions whose greatest dimensions are equal to or less than 15 percent of the parent metal thickness will be acceptable to the extent of one pore per inch of weld length.

10. Tungsten inclusions located in the penetration zone will be accepted provided the greatest dimension of any particle is not over 25 percent of the parent metal thickness.

11.3 Specifications Criteria for the Design and Fabrication of Facility Installations

The design, fabrication, and/or modification of the propellant storage area must be accompanied by a design and construction specification. This specification should include the following:

1. List of applicable drawings and specifications
2. Work schedule
3. Description and scope of work, and location
4. Materials of construction
5. Inspection and test requirements

The technical portion of the specification may be sectionalized as follows:

1. Civil and structural
2. Electrical
3. Mechanical

Each section should be detailed and complete in itself, and should include:

1. Material and workmanship
2. Specifications and standards
3. Allowable tolerances
4. Inspection requirements
5. Finish requirements
6. Definition of technical terms

The civil and structural section should include the following:

1. Buildings and structures
2. Concrete work
3. Area preparation, grading, and roads
4. Drainage system
5. Burn and collection basins
6. Reclamation sump
7. Inspection

The electrical section should include the following:

1. Power and lighting distribution
2. Transformers and switched distribution
3. Grounding, bonding, and lightning protection

4. Communications and warning systems
5. Electrical remote controls
6. Testing and inspection
7. Electrical instrumentation

The mechanical section should include the following:

1. Vessels and storage tanks
2. Piping and components lists and classification
3. Anchors and supports
4. Mechanical and pneumatic instrumentation
5. Welding of piping, vessels, etc.
6. Cleaning of tanks, piping, and components
7. Location and distribution of area safety equipment
8. Inspection and testing, including any performance tests

AD-	UNCLASSIFIED
Rocketdyne, a Division of North American Aviation, Inc., Canoga Park, California MECHANICAL SYSTEM DESIGN-CRITERIA MANUAL FOR HYDRAZINE by E. Suarez-Alfonso, A.E. Chambers, and D.J. Hatz. September 1961, 79 p incl. illus. (Proj. 3148, Task 30196) (AF/SSD-TR-61-6) (Contract AF 33(616)-6939) Unclassified report Presents criteria for the design and fabrication of a N_2H_4 storage facility. Consideration is given to the integrity of the storage system and personnel safety. (over)	1. Hydrazine 2. Design of liquid propellant storage facilities 3. Selection of materials and components for use with liquid propellants UNCLASSIFIED

AD-	UNCLASSIFIED
Rocketdyne, a Division of North American Aviation, Inc., Canoga Park, California MECHANICAL SYSTEM DESIGN-CRITERIA MANUAL FOR HYDRAZINE by E. Suarez-Alfonso, A.E. Chambers, and D.J. Hatz. September 1961, 79 p incl. illus. (Proj. 3148, Task 30196) (AF/SSD-TR-61-6) (Contract AF 33(616)-6939) Unclassified report Presents criteria for the design and fabrication of a N_2H_4 storage facility. Consideration is given to the integrity of the storage system and personnel safety. (over)	1. Hydrazine 2. Design of liquid propellant storage facilities 3. Selection of materials and components for use with liquid propellants UNCLASSIFIED

AD-	UNCLASSIFIED
Rocketdyne, a Division of North American Aviation, Inc., Canoga Park, California MECHANICAL SYSTEM DESIGN-CRITERIA MANUAL FOR HYDRAZINE by E. Suarez-Alfonso, A.E. Chambers, and D.J. Hatz. September 1961, 79 p incl. illus. (Proj. 3148, Task 30196) (AF/SSD-TR-61-6) (Contract AF 33(616)-6939) Unclassified report Presents criteria for the design and fabrication of a N_2H_4 storage facility. Consideration is given to the integrity of the storage system and personnel safety. (over)	1. Hydrazine 2. Design of liquid propellant storage facilities 3. Selection of materials and components for use with liquid propellants UNCLASSIFIED

AD-	UNCLASSIFIED
Rocketdyne, a Division of North American Aviation, Inc., Canoga Park, California MECHANICAL SYSTEM DESIGN-CRITERIA MANUAL FOR HYDRAZINE by E. Suarez-Alfonso, A.E. Chambers, and D.J. Hatz. September 1961, 79 p incl. illus. (Proj. 3148, Task 30196) (AF/SSD-TR-61-6) (Contract AF 33(616)-6939) Unclassified report Presents criteria for the design and fabrication of a N_2H_4 storage facility. Consideration is given to the integrity of the storage system and personnel safety. (over)	1. Hydrazine 2. Design of liquid propellant storage facilities 3. Selection of materials and components for use with liquid propellants UNCLASSIFIED

AD-	UNCLASSIFIED
The properties of N_2H_4 affecting the selection, design and fabrication of storage facilities and the selection of compatible materials of construction and control equipment are discussed. Procedures for testing, cleaning, and inspecting the storage system, or components thereof, are reported. In addition, the reactivation of existing facilities for use with N_2H_4 are discussed.	I. Suarez-Alfonso, E. II. Chambers, A.E. III. Hatz, D.J.
	UNCLASSIFIED

AD-	UNCLASSIFIED
The properties of N_2H_4 affecting the selection, design and fabrication of storage facilities and the selection of compatible materials of construction and control equipment are discussed. Procedures for testing, cleaning, and inspecting the storage system, or components thereof, are reported. In addition, the reactivation of existing facilities for use with N_2H_4 are discussed.	I. Suarez-Alfonso, E. II. Chambers, A.E. III. Hatz, D.J.
	UNCLASSIFIED

AD-	UNCLASSIFIED
The properties of N_2H_4 affecting the selection, design and fabrication of storage facilities and the selection of compatible materials of construction and control equipment are discussed. Procedures for testing, cleaning, and inspecting the storage system, or components thereof, are reported. In addition, the reactivation of existing facilities for use with N_2H_4 are discussed.	I. Suarez-Alfonso, E. II. Chambers, A.E. III. Hatz, D.J.
	UNCLASSIFIED

AD-	UNCLASSIFIED
The properties of N_2H_4 affecting the selection, design and fabrication of storage facilities and the selection of compatible materials of construction and control equipment are discussed. Procedures for testing, cleaning, and inspecting the storage system, or components thereof, are reported. In addition, the reactivation of existing facilities for use with N_2H_4 are discussed.	I. Suarez-Alfonso, E. II. Chambers, A.E. III. Hatz, D.J.
	UNCLASSIFIED

AD-	UNCLASSIFIED
Rocketdyne, a Division of North American Aviation, Inc., Canoga Park, California MECHANICAL SYSTEM DESIGN-CRITERIA MANUAL FOR HYDRAZINE by E. Suarez-Alfonso, A.E. Chambers, and D.J. Hatz. September 1961, 79 p incl. illus. (Proj. 3148, Task 30196) (AF/SSD-TR-61-6) (Contract AF 33(616)-6939) Unclassified report Presents criteria for the design and fabrication of a N_2H_4 storage facility. Consideration is given to the integrity of the storage system and personnel safety. (over)	1. Hydrazine 2. Design of liquid propellant storage facilities 3. Selection of materials and components for use with liquid propellants UNCLASSIFIED

AD-	UNCLASSIFIED
Rocketdyne, a Division of North American Aviation, Inc., Canoga Park, California MECHANICAL SYSTEM DESIGN-CRITERIA MANUAL FOR HYDRAZINE by E. Suarez-Alfonso, A.E. Chambers, and D.J. Hatz. September 1961, 79 p incl. illus. (Proj. 3148, Task 30196) (AF/SSD-TR-61-6) (Contract AF 33(616)-6939) Unclassified report Presents criteria for the design and fabrication of a N_2H_4 storage facility. Consideration is given to the integrity of the storage system and personnel safety. (over)	1. Hydrazine 2. Design of liquid propellant storage facilities 3. Selection of materials and components for use with liquid propellants UNCLASSIFIED

AD-	UNCLASSIFIED
Rocketdyne, a Division of North American Aviation, Inc., Canoga Park, California MECHANICAL SYSTEM DESIGN-CRITERIA MANUAL FOR HYDRAZINE by E. Suarez-Alfonso, A.E. Chambers, and D.J. Hatz. September 1961, 79 p incl. illus. (Proj. 3148, Task 30196) (AF/SSD-TR-61-6) (Contract AF 33(616)-6939) Unclassified report Presents criteria for the design and fabrication of a N_2H_4 storage facility. Consideration is given to the integrity of the storage system and personnel safety. (over)	1. Hydrazine 2. Design of liquid propellant storage facilities 3. Selection of materials and components for use with liquid propellants UNCLASSIFIED

AD-	UNCLASSIFIED
Rocketdyne, a Division of North American Aviation, Inc., Canoga Park, California MECHANICAL SYSTEM DESIGN-CRITERIA MANUAL FOR HYDRAZINE by E. Suarez-Alfonso, A.E. Chambers, and D.J. Hatz. September 1961, 79 p incl. illus. (Proj. 3148, Task 30196) (AF/SSD-TR-61-6) (Contract AF 33(616)-6939) Unclassified report Presents criteria for the design and fabrication of a N_2H_4 storage facility. Consideration is given to the integrity of the storage system and personnel safety. (over)	1. Hydrazine 2. Design of liquid propellant storage facilities 3. Selection of materials and components for use with liquid propellants UNCLASSIFIED

AD-	UNCLASSIFIED
The properties of N_2H_4 affecting the selection, design and fabrication of storage facilities and the selection of compatible materials of construction and control equipment are discussed. Procedures for testing, cleaning, and inspecting the storage system, or components thereof, are reported. In addition, the reactivation of existing facilities for use with N_2H_4 are discussed.	I. Suarez-Alfonso, E. II. Chambers, A.E. III. Hatz, D.J.
	UNCLASSIFIED

AD-	UNCLASSIFIED
The properties of N_2H_4 affecting the selection, design and fabrication of storage facilities and the selection of compatible materials of construction and control equipment are discussed. Procedures for testing, cleaning, and inspecting the storage system, or components thereof, are reported. In addition, the reactivation of existing facilities for use with N_2H_4 are discussed.	I. Suarez-Alfonso, E. II. Chambers, A.E. III. Hatz, D.J.
	UNCLASSIFIED

AD-	UNCLASSIFIED
The properties of N_2H_4 affecting the selection, design and fabrication of storage facilities and the selection of compatible materials of construction and control equipment are discussed. Procedures for testing, cleaning, and inspecting the storage system, or components thereof, are reported. In addition, the reactivation of existing facilities for use with N_2H_4 are discussed.	I. Suarez-Alfonso, E. II. Chambers, A.E. III. Hatz, D.J.
	UNCLASSIFIED

AD-	UNCLASSIFIED
The properties of N_2H_4 affecting the selection, design and fabrication of storage facilities and the selection of compatible materials of construction and control equipment are discussed. Procedures for testing, cleaning, and inspecting the storage system, or components thereof, are reported. In addition, the reactivation of existing facilities for use with N_2H_4 are discussed.	I. Suarez-Alfonso, E. II. Chambers, A.E. III. Hatz, D.J.
	UNCLASSIFIED

UNCLASSIFIED

UNCLASSIFIED