AD NUMBER: AD0301411
LIMITATION CHANGES
TO: Approved for public release; distribution is unlimited.
FROM: Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; 22 Dec 1957. Other requests shall be referred to Ordnance Corps (Army), Washington DC
AUTHORITY
St A USAMC ltr 20 May 1971

AD NUMBER: AD0301411
CLASSIFICATION CHANGES
TO: Unclassified
FROM: Confidential
AUTHORITY
C to U DoDD 5200.10 31 Dec 1969

CONFIDENTIAL

MEMORANDUM NO. 20-152

A SURVEY OF THE COMPATIBILITY OF VARIOUS MATERIALS WITH HYDRAZINE AND MIXTURES OF HYDRAZINE, HYDRAZINE NITRATE, AND WATER

DONALD H. LEE

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA
DECEMBER 22, 1957

CONFIDENTIAL 58AA 8100

CONFIDENTIAL

ORDCIT Project
Contract No. DA-04-495-Ord 18
Department of the Army
ORDNANCE CORPS

MEMORANDUM NO. 20-152

A SURVEY OF THE COMPATIBILITY OF VARIOUS MATERIALS WITH HYDRAZINE AND MIXTURES OF HYDRAZINE, HYDRAZINE NITRATE, AND WATER

Donald H. Lee

Arthur F. Grant, Jr.

Arthur F. Grant, Jr., *Chief*
Power Plant Research Section

Copy No. A 82

JET PROPULSION LABORATORY
California Institute of Technology
Pasadena, California
December 23, 1957

58AA 8100

CONFIDENTIAL

CONTENTS

CONTENTS (Cont'd)

THIS REPORT HAS BEEN DISTRIBUTED ACCORDING TO SECTION A, WITH ABSTRACTS TO SECTIONS C AND DP, OF THE SUBCOMMITTEE ON ANAF/GM MAILING LIST, OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE (RESEARCH AND DEVELOPMENT), GUIDED MISSILE TECHNICAL INFORMATION DISTRIBUTION LIST, MML 200/14, LIST NO. 14, DATED 1 JUNE 1957.

ABSTRACT

A compilation and an evaluation of experimental data obtained from the available literature are presented on the compatibility of various metals, plastics and elastomers, and miscellaneous materials with hydrazine and hydrazine–hydrazine nitrate–water mixtures. An effort has been made to present this material in a condensed tabular form for ready reference and also in sufficient detail to outline the limitations of the test data.

I. INTRODUCTION

In order that hydrazine and hydrazine-rich mixtures may be used to full advantage as rocket fuels or gas generants, their compatibility with various materials must be known. A great quantity of research and development work on hydrazine has been accomplished since the compound was determined to have practical application. In virtually all cases, the organization doing the work has conducted an independent experimental program to obtain information on the compatibility of hydrazine with various materials, in order that suitable facilities and equipment might be constructed. This information is available in varying quantities in numerous reports. However, for the user entering into the application of hydrazine for the first time, the acquisition of a working knowledge of compatible materials for the job at hand is rather time consuming. The purpose of this Memorandum is to consolidate and, where possible, to evaluate in an easily referable form all of the compatibility information that is readily available concerning hydrazine and hydrazine–hydrazine nitrate-water mixtures.

ABSTRACT

A compilation and an evaluation of experimental data obtained from the available literature are presented on the compatibility of various metals, plastics and elastomers, and miscellaneous materials with hydrazine and hydrazine–hydrazine nitrate–water mixtures. An effort has been made to present this material in a condensed tabular form for ready reference and also in sufficient detail to outline the limitations of the test data.

I. INTRODUCTION

In order that hydrazine and hydrazine-rich mixtures may be used to full advantage as rocket fuels or gas generants, their compatibility with various materials must be known. A great quantity of research and development work on hydrazine has been accomplished since the compound was determined to have practical application. In virtually all cases, the organization doing the work has conducted an independent experimental program to obtain information on the compatibility of hydrazine with various materials, in order that suitable facilities and equipment might be constructed. This information is available in varying quantities in numerous reports. However, for the user entering into the application of hydrazine for the first time, the acquisition of a working knowledge of compatible materials for the job at hand is rather time consuming. The purpose of this Memorandum is to consolidate and, where possible, to evaluate in an easily referable form all of the compatibility information that is readily available concerning hydrazine and hydrazine–hydrazine nitrate–water mixtures.

II. FACTORS IN EVALUATING COMPATIBILITY

The compilation of materials-compatibility information for anhydrous hydrazine, hydrazine hydrate, and hydrazine–hydrazine nitrate–water mixtures has been a lengthy but straightforward task; however, a complete evaluation of the compatibility of a particular material has, in many cases, not been possible because of inadequate test data or because of th inability to define a universally applicable standard of compatibility. In describing the compatibility of a particular material with hydrazine, the following factors must be taken into consideration:

1. The effects of hydrazine on the material, as evidenced by a loss or gain in the weight of the material, a color change, a dimensional change, loss of elastomeric properties, etc.

2. The effect of the material on the rate of decomposition of hydrazine, as evidenced by a pressure rise in sealed containers, the evolution of gas, a change in the composition, weight, or color of the liquid, etc. Ions, oxides, or the leaching of constituents from the material may influence the autodecomposition of hydrazine.

Both of these factors are, in turn, influenced by initial hydrazine purity, the temperature at which contact occurs, the duration of contact, and the surface area of the material in contact with the hydrazine.

When consideration is given to all these factors, there are few materials which can be judged completely compatible with hydrazine. In almost all cases, the suitability of a material becomes a matter of the specific application. A particular metal may be satisfactory for an application where air oxidation of the metal surface can be reliably avoided, whereas it may be completely unacceptable for a similar application in which prolonged exposure to air cannot be avoided.

The existence of varying degrees of compatibility makes a simple presentation of materials acceptability difficult and, in many cases, misleading. The presentation of a compatibility evaluation in chart form only, describing materials as being either good or bad, does not give the user much leeway on material selection, nor does it supply all the information that he should possess before employing a material in a particular application. For this reason, the data compiled herein are presented both in a condensed summary form for ready reference and also in detail, so that the limitations of the test data are readily apparent.

III. COMPARATIVE COMPATIBILITY OF VARIOUS MATERIALS

It is the purpose of this Section to present, in condensed-summary form (Table 1), the present author's evaluations of the compatibility data available for numerous metals, plastics and elastomers, and miscellaneous materials.

In Table 1, the following symbols are used to represent varying degrees of compatibility:

A—Material is acceptable for general service.

B—Material is acceptable for limited service. See Sec. IV for specific limitations.

C—Material should be avoided. See Sec. IV for data on which this conclusion is based.

Table 1. Summary of the Comparative Compatibility of Various Materials With Hydrazine and Hydrazine Mixtures

Material	Anhydrous Hydrazine	Hydrazine Hydrate	Hydrazine–Hydrazine Nitrate–Water Mixtures	Material	Anhydrous Hydrazine	Hydrazine Hydrate	Hydrazine–Hydrazine Nitrate–Water Mixtures
				Metals			
				Nickel-chrome alloys (Chromel-A, Nichrome)	[illegible]	B	C
Aluminum				Silver	B	B	B
2S	A	A	B	Steel			
2SO	A	A	B	Mild	C	C	C
2SH	A	A	B	Stainless			
3S	A	A	B	302	B	B	B
3SH	A	A	B	303	C	C	C
24ST	A	A	A	304	A	A	A
40E	B	B	B	315	C	C	C
43	B	B	B	316	C	C	C
52ST	A	A	A	317	C	C	C
61ST	A	A	A	321	B	B	B
75ST	A	A	A	329	C	C	C
XA-345	B	B	B	347	A	A	A
716	B	B	B	410	B	B	B
Brass	B	B	B	416	C	C	C
Cobalt	C	C	C	420F	C	C	C
Copper	C	C	C	430	B	B	B
Inconel	B	B	B	430F	C	C	C
Inconel X	B	B	B	440A	C	C	C
Iron	C	C	C	440C	C	C	C
Lead	C	C	C	W	B	B	B
Magnesium	C	C	C	Stellite	B	B	B
Manganese	C	C	C	Tantalum	A	A	A
Molybdenum	C	C	C	Tin	C	C	C
Monel	B	B	C	Titanium	A	A	A
Nickel	B	B	C	Zinc	C	C	C

Table 1 (Cont'd)

Material	Anhydrous Hydrazine	Hydrazine Hydrate	Hydrazine–Hydrazine Nitrate–Water Mixtures	Material	Anhydrous Hydrazine	Hydrazine Hydrate	Hydrazine–Hydrazine Nitrate–Water Mixtures
Plastics and Elastomers							
Cellulose acetate	C	C	C	Polyvinyl alcohol	C	C	C
Diallyl phthalate	C	C	C	Polyvinyl chloride (Koroseal, Vinylite, etc.)	B	B	B
Epon	B	B	B	Rubber			
Ethyl cellulose	B	B	B	Natural gum	C	C	C
Furane resin	B	B	B	Synthetic	B	B	B
Hycar	B	B	B	Saran	C	C	C
Kel-F	B	B	B	Silastic	B	B	B
Lactoprene	C	C	C	Teflon	A	A	A
Lucite	B	B	B	Tygon	B	B	B
Melamine formaldehyde	B	B	B	U.S. Rubber Plastic			
Nylon	B	B	B	L7825	B	B	B
Phenolic	B	B	B	M20995	B	B	B
Polyester	C	C	C	Velaform	C	C	C
Polyethylene	A	A	A				
Polystyrene and polydichlorostyrene	C	C	B				
Miscellaneous Materials							
Asbestos	B	B	B	Silicone lubricants			
Glass				DC-200 series	B	B	B
Soft	A	A	A	DC-550	B	B	B
Pyrex	A	A	A	DC-710	B	B	B
Graphite	B	B	B	Plug-cock grease	B	B	B
Graphitar	B	B	B	Solder			
Pipe-joint compounds				Lead-tin	B	B	B
AN-C-53	B	B	B	Silver	B	B	B
Oxyseal	B	B	B	Varnish	B	B	B
Thread-Tite	B	B	B	Wood	C	C	C
Rags	C	C	C	Wool	C	C	C

IV. COMPILATION AND EVALUATION OF EXPERIMENTAL DATA

A. Metals

1. Aluminum. Aluminum and a number of aluminum alloys are considered to be suitable for general use with hydrazine and hydrazine–hydrazine nitrate–water mixtures containing as much as 20 to 30% hydrazine nitrate.

Picatinny Arsenal reports that aluminum alone, of all common metals tested, was unaffected after storage for 1 yr in anhydrous hydrazine, both at room temperature and at 149°F. Data from the Naval Ordnance Laboratory also indicate that aluminum was unaffected and had not significantly contributed to the decomposition of anhydrous hydrazine after contact for 1 yr at ambient temperatures. The data from other agencies are for tests of shorter duration, but, in general, substantiate these results within the time limits of the tests. Grades of aluminum for which at least some data exist and which, it is believed, can be used without restriction with anhydrous hydrazine are 2S, 2SO, 2SH, 3S and 3SH.

Data for aluminum alloys in contact with anhydrous hydrazine do not cover as lengthy periods of time as do those for pure aluminum. However, from the results of the tests, it is believed that aluminum alloys 75ST, 24ST, 52ST, and 61ST are all satisfactory, but should be given preference in the order shown. Experimental data are meager with regard to aluminum alloys 40E, 43, XA-545, and 716. Until additional data are available, it is concluded that alloys 43, XA-545, and 716 should be considered suitable only for short term application, but that 40E should be avoided because of the possibility that zinc might be leached from the alloy.

Test results for commercially pure aluminum with hydrazine nitrate mixtures have not been completely consistent. The Naval Ordnance Laboratory obtained varying data which indicated decreasing compatibility as the percentage of hydrazine nitrate was increased. However, this organization recommended that additional testing should be undertaken to clarify the results. The Navord data, as well as data from Mathiesen Chemical Corporation, indicate the acceptability of aluminum with hydrazine–hydrazine nitrate–water mixtures containing approximately 20 to 30% hydrazine nitrate. It is believed that 2S, 2SH, and 3S aluminum should be considered completely acceptable in contact with hydrazine nitrate concentrations up to the percentages noted above, but that additional data should be obtained for long-term compatibility of the more concentrated nitrate mixtures.

The aluminum alloys 24ST, 52ST, 61ST, and 75ST appear to have been generally unaffected by the hydrazine nitrate mixtures and did not significantly influence the stability of these propellants. Consequently, it is considered that all these alloys are acceptable, but should be used in the same order of preference previously indicated for anhydrous hydrazine (75ST, 24ST, 52ST, and 61ST).

The apparent high degree of compatibility exhibited by aluminum in contact with hydrazine may result from the fact that aluminum ions are apparently noncatalytic in the decomposition of hydrazine (Ref. 1). It has also been reported (Ref. 2) that aluminum oxide (Al_2O_3) has a remarkable stabilizing effect upon hydrazine. Aluminum oxide formed on the metal surface may act as a buffer. In this respect, it would appear that anodization of aluminum in contact with hydrazine would be advantageous. Only one test is reported for anodized aluminum. In this test, which was performed with 45.0 wt % $N_2H_5NO_3$ and 9.9 wt % H_2O in N_2H_4 at 162 to 165°F, no reaction other than a slight discoloration of the solution was observed after 7 days.

Experimental Data

Material tested: Aluminum 2S (Alcoa 2S, 99% Al)
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Rolled sheet
Propellant: Anhydrous hydrazine (95.09%)
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 77°F)
Time: 120 hr
Results: Negligible corrosion was observed.

Material tested: Aluminum 2SO
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric

IV. COMPILATION AND EVALUATION OF EXPERIMENTAL DATA

A. Metals

1. Aluminum. Aluminum and a number of aluminum alloys are considered to be suitable for general use with hydrazine and hydrazine–hydrazine nitrate–water mixtures containing as much as 20 to 30% hydrazine nitrate.

Picatinny Arsenal reports that aluminum alone, of all common metals tested, was unaffected after storage for 1 yr in anhydrous hydrazine, both at room temperature and at 149°F. Data from the Naval Ordnance Laboratory also indicate that aluminum was unaffected and had not significantly contributed to the decomposition of anhydrous hydrazine after contact for 1 yr at ambient temperatures. The data from other agencies are for tests of shorter duration, but, in general, substantiate these results within the time limits of the tests. Grades of aluminum for which at least some data exist and which, it is believed, can be used without restriction with anhydrous hydrazine are 2S, 2SO, 2SH, 3S and 3SH.

Data for aluminum alloys in contact with anhydrous hydrazine do not cover as lengthy periods of time as do those for pure aluminum. However, from the results of the tests, it is believed that aluminum alloys 75ST, 24ST, 52ST, and 61ST are all satisfactory, but should be given preference in the order shown. Experimental data are meager with regard to aluminum alloys 40E, 43, XA-545, and 716. Until additional data are available, it is concluded that alloys 43, XA-545, and 716 should be considered suitable only for short term application, but that 40E should be avoided because of the possibility that zinc might be leached from the alloy.

Test results for commercially pure aluminum with hydrazine nitrate mixtures have not been completely consistent. The Naval Ordnance Laboratory obtained varying data which indicated decreasing compatibility as the percentage of hydrazine nitrate was increased. However, this organization recommended that additional testing should be undertaken to clarify the results. The Navord data, as well as data from Mathiesen Chemical Corporation, indicate the acceptability of aluminum with hydrazine–hydrazine nitrate–water mixtures containing approximately 20 to 30% hydrazine nitrate. It is believed that 2S, 2SH, and 3S aluminum should be considered completely acceptable in contact with hydrazine nitrate concentrations up to the percentages noted above, but that additional data should be obtained for long-term compatibility of the more concentrated nitrate mixtures.

The aluminum alloys 24ST, 52ST, 61ST, and 75ST appear to have been generally unaffected by the hydrazine nitrate mixtures and did not significantly influence the stability of these propellants. Consequently, it is considered that all these alloys are acceptable, but should be used in the same order of preference previously indicated for anhydrous hydrazine (75ST, 24ST, 52ST, and 61ST).

The apparent high degree of compatibility exhibited by aluminum in contact with hydrazine may result from the fact that aluminum ions are apparently noncatalytic in the decomposition of hydrazine (Ref. 1). It has also been reported (Ref. 2) that aluminum oxide (Al_2O_3) has a remarkable stabilizing effect upon hydrazine. Aluminum oxide formed on the metal surface may act as a buffer. In this respect, it would appear that anodization of aluminum in contact with hydrazine would be advantageous. Only one test is reported for anodized aluminum. In this test, which was performed with 45.0 wt % $N_2H_5NO_3$ and 9.9 wt % H_2O in N_2H_4 at 162 to 165°F, no reaction other than a slight discoloration of the solution was observed after 7 days.

Experimental Data

Material tested: Aluminum 2S (Alcoa 2S, 99% Al)
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Rolled sheet
Propellant: Anhydrous hydrazine (95.0%)
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 77°F)
Time: 120 hr
Results: Negligible corrosion was observed.

Material tested: Aluminum 2SO
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric

Temperature: 20°C (68°F)
Time: 24 days
Results: No change was noted in the specimen or the solution.

Material tested: Aluminum 2S
Source of data: Ref. 5
Number of samples tested: 4
Shape of samples: Strip, 10 mm × 100 mm × 3 mm
Propellants: 97.5% N_2H_4–1.9% H_2O–0.6% NH_3
78.4% N_2H_4–18.1% $N_2H_5NO_3$–3% H_2O–0.5% NH_3
44.9% N_2H_4–45.3% $N_2H_5NO_3$–9.4% H_2O–0.4% NH_3
19.6% N_2H_4–78.4% $N_2H_5NO_3$–1.8% H_2O–0.2% NH_3
Pressure: Closed system, initially atmospheric
Temperature: Ambient
Time: 36 to 344 days
Results: The results of this test are varied, depending on the particular solution used. The test of 2S in the 45–45–10 mixture exhibited a large and rapid gas formation. The test was discontinued after 112 days, when 202 ml of gas had been collected. There was a large reduction in the weight of the strip, and extensive corrosion, mostly in the vapor phase, had occurred. The composition of the solution had not changed materially.

The test of 2S in the 19.6–78.4–1.8 solution showed a rapid rate of pressure rise for the first 36 days. At this time, the flask was accidentally broken. Subsequent retest of 2S in this solution showed no abnormal rate of pressure rise; however, at the end of 344 days, 15 cc of gas had been evolved as compared with the 9.6 cc obtained from the control solution after 384 days. These data, plus the fact that there was a greater reduction of $N_2H_5NO_3$ concentration in the test solution than in the control solution, indicate that the 2S increased the rate of decomposition. The strip showed a white incrustation at the immersed part, but only slight attack.

In anhydrous hydrazine and in the 78.4–18.1–3 solution, the strips were apparently unaffected, with the exception that the 78.4–18.1–3 sample showed slight discoloration. Sample-weight differences were negligible and the composition of the solutions had not altered significantly from that of the controls.

NAVORD recommends that a final conclusion regarding the compatibility of 2S aluminum with the hydrazine nitrate solutions should await further tests. Its use with anhydrous hydrazine appears acceptable.

Material tested: Aluminum 2S
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Slightly over 2% of the hydrazine was decomposed.

Material tested: Aluminum 2S
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 30 days
Results: Approximately 4% of the hydrazine was decomposed. This was about the same as that noted in the blank run in glass.

Material tested: Aluminum 2S
Source of data: Ref. 6
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 4 mo
Results: The sample was unaffected and did not decompose the hydrazine to any extent.

Material tested: Aluminum 2SH-14
Source of data: Ref. 7
Number of samples tested: 3
Shape of samples: Strip, 2 in. × ½ in. × 1/16 in.

Propellants: 95% N_2H_4–5% H_2O
65% N_2H_4–30% $N_2H_5NO_3$–5% H_2O
60% N_2H_4–30% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 60°C (140°F)
Time: 2 wk
Results: A slight weight increase (0.03%) and a slight scale formation at the liquid–vapor interface occurred with the anhydrous hydrazine solution; the hydrazine remained colorless. No weight change took place in the hydrazine nitrate solution with 5% water, but a slight yellowing of the solution was observed. A weight loss of 0.01% was noted in the hydrazine nitrate solution with 10% water, and the solution showed yellowing. The color change is believed due to the presence of traces of aniline in the hydrazine. No dimensional changes occurred in any samples.

Material tested: Aluminum 3S
Source of data: Ref. 8
Number of samples tested: 2
Shape of samples: Strip
Propellant: 70% N_2H_4–25% $N_2H_5NO_3$–5% H_2O
Pressure: Atmospheric
Temperature: 71°C (160°F)
Time: 9 wk
Results: The test solution had not changed significantly, and the specimen appeared unaffected.

Material tested: Aluminum 3S
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 1.5% of the hydrazine was decomposed.

Material tested: Aluminum 3S
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 30 days
Results: The hydrazine was approximately 9% decomposed.

Material tested: Aluminum 3SH-14
Source of data: Ref. 7
Number of samples tested: 3
Shape of samples: Strip, 2 in. × ½ in. × 1/16 in.
Propellants: 95% N_2H_4–5% H_2O
65% N_2H_4–30% $N_2H_5NO_3$–5% H_2O
60% N_2H_4–30% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 60°C (140°F)
Time: 2 wk
Results: A weight increase of 0.01% occurred in the specimen tested in the anhydrous hydrazine solution, accompanied by some scale at the liquid–vapor interface. The solution remained colorless. In both the hydrazine nitrate mixtures, the samples showed a weight loss of 0.02%, accompanied by yellowing of the solution. The yellowing is believed due to the trace presence of aniline. No change occurred in the size of any of the samples.

Material tested: Aluminum
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip, 5 cm × 1 cm × 0.4 cm
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 12 mo
Results: No change was observed in the weight or appearance of the sample at the end of 12 mo.

Material tested: Aluminum
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip, 5 cm × 1 cm × 0.4 cm
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: 12 mo
Results: No change had occurred in the weight or appearance of the sample at the end of 12 mo.

Material tested: Anodized aluminum (green)
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Strip
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (162 to 165°F)
Time: 7 days
Results: A color change took place in the solution. Otherwise, no reaction was apparent.

Material tested: Aluminum 24ST
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: No change was observed in the specimen or the solution.

Material tested: Aluminum 24ST
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Strip
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (162 to 165°F)
Time: 7 days
Results: No loss or gain in weight was noted. The specimen apparently remained unaffected.

Material tested: Aluminum 24ST-3
Source of data: Ref. 7
Number of samples tested: 3
Shape of samples: Strip, 2 in. × ½ in. × 1/16 in.
Propellants: 95% N_2H_4–5% H_2O
65% N_2H_4–30% $N_2H_5NO_3$–5% H_2O
60% N_2H_4–30% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 60°C (140°F)
Time: 2 wk
Results: A weight increase of 0.07% was noted for the specimen in the anhydrous hydrazine, with a slight scale formation at the liquid–vapor interface. No change occurred in the color of the solution. The sample in the hydrazine nitrate solution with 10% H_2O showed a 0.20% weight gain. Both solutions had turned yellow; this was believed due to the presence of traces of aniline. No change in dimension occurred for any of the samples.

Material tested: Aluminum 24ST
Source of data: Ref. 11
Number of samples tested: 3
Shape of samples: 8-cc bomb of 24ST alloy with pressure gage, 50% ullage
Propellants: 98% N_2H_4–2% H_2O
65% N_2H_4–30% $N_2H_5NO_3$–5% H_2O
60% N_2H_4–30% $N_2H_5NO_3$–10% H_2O
Pressure: Initially atmospheric
Temperature: 60°C (140°F)
Time: 30 days
Results: During the initial heating period, the pressures in the bombs rose rapidly to 4 to 8.5 psig. The rate of pressure rise decreased with time for all the bombs. The rate for the anhydrous hyrazine averaged 0.17 psi/day, based on final pressure at 18°C. The bomb containing the hydrazine nitrate mixture with 5% water showed an average pressure rise of 0.13 psi/day. The bomb containing the hydrazine nitrate mixture with 10% water showed an average pressure rise of 0.17 psi/day. It is believed that most of the initial pressure rise was due to NH_3 vapor pressure.

Material tested: Aluminum 24S
Source of data: Ref. 12
Number of samples tested: 2
Shape of samples: Strip
Propellant: Eutectic hydrazine (actual N_2H_4–H_2O proportions not given)
Temperature: Ambient
Time: 30 days
Results: With hydrazine from Mathieson, there was a heavy brown deposit on the specimen. With hydrazine from Fairmount, the material was black and badly corroded.

Material tested: Aluminum 24S
Source of data: Ref. 12
Number of samples tested: 2
Shape of samples: Strip

Propellant: Eutectic hydrazine (N_2H_4–H_2O proportions not given)
Pressure: Atmospheric
Temperature: 49°C (120°F)
Time: 30 days
Results: The specimen in Mathieson hydrazine had a light brown deposit. The specimen in Fairmount hydrazine was black and badly corroded.

Material tested: Aluminum 40E (5% Zn, 0.5% Cr, 0.2% Ti, 1.0% Fe, 0.4% Cu, 0.3% Mn, 0.3% Si, balance Al)
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Cast section
Propellant: Hydrazine hydrate (66% N_2H_4)
Pressure: Atmospheric
Temperature: 14 to 24°C (57 to 75°F)
Time: 67.5 hr
Results: Slight corrosion occurred, causing a 0.07% change in weight. Zinc-bearing alloys should be avoided.

Material tested: Aluminum 43 (5.0% Si, 0.8% max Fe)
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Cast section
Propellant: Hydrazine hydrate (66% N_2H_4)
Pressure: Atmospheric
Temperature: 14 to 25°C (57 to 77°F)
Time: 67.5 hr
Results: The surface of the sample turned blue. No change occurred in the weight of the sample.

Material tested: Aluminum 52ST
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Strip
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (162 to 165°F)
Time: 7 days
Results: No loss or gain in the weight of the samples was observed.

Material tested: Aluminum 52ST
Source of data: Ref. 8
Number of samples tested: 2
Shape of samples: Strip
Propellant: 70% N_2H_4–25% $N_2H_5NO_3$–5% H_2O
Pressure: Atmospheric
Temperature: 71°C (160°F)
Time: 9 wk
Results: The test solution had not changed significantly, and the specimens appeared unaffected.

Material tested: Aluminum 52SH-34
Source of data: Ref. 7
Number of samples tested: 3
Shape of samples: Strip, 2 in. × ½ in. × 1/16 in.
Propellants: 95% N_2H_4–5% H_2O
65% N_2H_4–30% $N_2H_5NO_3$–5% H_2O
60% N_2H_4–30% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 60°C (140°F)
Time: 2 wk
Results: The samples showed a 0.03% weight increase in anhydrous hydrazine, with slight scale at the interface, but no solution discoloration. The tests in both hydrazine nitrate solutions showed 0.01% weight losses and solution yellowing. The yellowing is believed to be caused by trace quantities of aniline. No change in the dimensions of any of the samples was noted.

Material tested: Aluminum 61ST
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Strip
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (162 to 165°F)
Time: 7 days
Results: No loss or gain in weight was noted in either specimen.

Material tested: Aluminum 61ST
Source of data: Ref. 8
Number of samples tested: 2
Shape of samples: Strip
Propellant: 70% N_2H_4–25% $N_2H_5NO_3$–5% H_2O
Pressure: Atmospheric
Temperature: 71°C (160°F)
Time: 9 wk
Results: The samples were slightly tarnished and showed

a slight weight increase. The test solution had not changed significantly.

Material tested: Aluminum 61ST-6
Source of data: Ref. 7
Number of samples tested: 3
Shape of samples: Strip, 2 in. × ½ in. × 1/16 in.
Propellants: 95% N_2H_4–5% H_2O
65% N_2H_4–30% $N_2H_5NO_3$–5% H_2O
60% N_2H_4–30% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 60°C (140°F)
Time: 2 wk
Results: The sample in the anhydrous hydrazine solution showed a 0.06% weight increase and a slight scale at the vapor–liquid interface. No solution discoloration was noted. The sample in the hydrazine nitrate solution with 5% water showed no weight change. The sample in the hydrazine nitrate solution with 10% water showed a 0.02% weight increase. Both solutions were slightly yellow; this is believed due to the presence of aniline. No change in the size of any of the samples was noted.

Material tested: Aluminum 61ST
Source of data: Ref. 11
Number of samples tested: 3
Shape of samples: 8-cc bomb of 61ST alloy with pressure gage, 50% ullage
Propellants: 98% N_2H_4–2% H_2O
65% N_2H_4–30% $N_2H_5NO_3$–5% H_2O
60% N_2H_4–30% $N_2H_5NO_3$–10% H_2O
Pressure: Initially atmospheric
Temperature: 60°C (140°F)
Time: 30 days
Results: During the initial heating period, pressures rose to 6 to 8 psig. The rate of pressure rise decreased with time for all the bombs. The average rate of pressure rise over the 30-day test of the anhydrous hydrazine, based on a final temperature of 18°C, was 0.22 psi/day. The 5% and 10% water mixtures of hydrazine nitrate showed average pressure rises of 0.18 psi/day.

Material tested: Aluminum 75ST-6
Source of data: Ref. 7
Number of samples tested: 3
Shape of samples: Strip, 2 in. × ½ in. × 1/16 in.
Propellants: 95% N_2H_4–5% H_2O
65% N_2H_4–30% $N_2H_5NO_3$–5% H_2O
60% N_2H_4–30% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 60°C (140°F)
Time: 2 wk
Results: The samples in anhydrous hydrazine showed a 0.04% weight increase, and a slight scale at the liquid–vapor interface, but no change in solution color. The sample in hydrazine nitrate solution with 5% water showed no weight change. The sample in hydrazine nitrate solution with 10% water showed a 0.01% weight increase. Both hydrazine nitrate solutions turned yellow. It is believed that the yellowing was due to trace quantities of aniline. No change in size was noted for any of the samples.

Material tested: Aluminum 75ST-6 (Alclad)
Source of data: Ref. 7
Number of samples tested: 3
Shape of samples: Strip, 2 in. × ½ in. × 1/16 in.
Propellants: 95% N_2H_4–5% H_2O
65% N_2H_4–30% $N_2H_5NO_3$–5% H_2O
60% N_2H_4–30% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 60°C (140°F)
Time: 2 wk
Results: The test in anhydrous hydrazine was interrupted before a weight change was noted. The solution remained colorless, however. Both hydrazine nitrate solutions turned yellow, but the sample showed no weight change. The yellowing was believed due to the presence of aniline. No dimensional changes in the samples were noted.

Material tested: Aluminum 75ST
Source of data: Ref. 11
Number of samples tested: 3
Shape of samples: 8-cc bomb of 75ST alloy with pressure gage, 50% ullage
Propellants: 98% N_2H_4–2% H_2O
65% N_2H_4–30% $N_2H_5NO_3$–5% H_2O
60% N_2H_4–30% $N_2H_5NO_3$–10% H_2O
Pressure: Initially atmospheric
Temperature: 60°C (140°F)

Time: 30 days

Results: During the initial heating period, a pressure rise of 3.5 to 9 psig was noted. The rate of pressure rise decreased with time for all the bombs. The average rate of pressure rise over the 30-day period for anhydrous hydrazine, based on a final temperature of 18°C, was 0.10 psi/day. The hydrazine nitrate mixture with 5% water showed the same average pressure rise. The hydrazine nitrate mixture with 10% water gave an average pressure rise over the 30-day period of 0.12 psi/day. It is of interest to note that 75ST aluminum had a lower average pressure rise than did 24ST or 61ST, which were tested in the same manner.

Material tested: Aluminum 75ST

Source of data: Ref. 13

Shape of sample: 8-cc cylinder of 75ST with pressure gage, 10% ullage

Propellants: 100% N_2H_4
70% N_2H_4–30% $N_2H_5NO_3$
80% N_2H_4–20% HNO_3
60% N_2H_4–30% $N_2H_5NO_3$–10% H_2O

Pressure: Initially atmospheric

Temperature: 60°C (140°F)

Time: 3 mo

Results: An initial pressure rise of 5 to 10 psig occurred within the first few hours, apparently resulting from the vapor pressure of ammonia present in the propellant and not from decomposition. Slight decomposition occurred, as evidenced by a gradual increase in pressure; however, the rate of decomposition decreased with time.

Material tested: Aluminum XA-545

Source of data: Ref. 7

Number of samples tested: 3

Shape of samples: Strip, 2 in. × ¼ in. × 1/16 in.

Propellants: 95% N_2H_4–5% H_2O
65% N_2H_4–30% $N_2H_5NO_3$–5% H_2O
60% N_2H_4–30% $N_2H_5NO_3$–10% H_2O

Pressure: Atmospheric

Temperature: 60°C (140°F)

Time: 2 wk

Results: The sample in anhydrous hydrazine showed a 0.04% weight increase; a slight scale appeared at the vapor–liquid interface; no color change was observed in the solution. The hydrazine nitrate solutions turned yellow, probably because of the trace presence of aniline, but the samples showed no weight change. None of the samples showed any changes in dimension.

Material tested: Aluminum 716 (Alcoa welding-rod designation)

Source of data: Ref. 6

Number of samples tested: 1 or 2

Shape of samples: Strip

Propellant: Anhydrous hydrazine (95.5%)

Pressure: Closed system, initially atmospheric

Temperature: 26°C (80°F)

Time: 30 days

Results: Approximately 2% hydrazine decomposition was observed (about ½% more than that noted in the blank run in glass).

Material tested: Aluminum 716 (Alcoa welding-rod designation)

Source of data: Ref. 6

Number of samples tested: 1 or 2

Shape of samples: Strip

Propellant: Anhydrous hydrazine (95.5%)

Pressure: Closed system, initially atmospheric

Temperature: 60°C (140°F)

Time: 30 days

Results: Approximately 4% hydrazine decomposition was observed (about the same as that noted in the blank run in glass).

2. Brass. It is believed that brass should be avoided for general use with hydrazine and should be avoided completely with hydrazine nitrate mixtures. From a corrosion standpoint, it is believed that contact periods should not exceed a duration of a few months. Mathieson Chemical Corporation determined, during the course of thermal-decomposition studies of anhydrous hydrazine in a brass bomb at temperatures up to 500°F, that there was an apparent leaching-out of the zinc after several consecutive tests. The interior surface of the bomb had the appearance of copper (Ref. 11).

In view of the large proportion of copper present in brass, it would appear that some difficulties might be encountered under conditions where the copper might be oxidized in air. These oxides would be capable of exothermic reduction by hydrazine.

As indicated below, brass appeared to be unsatisfactory in contact with a 45–45–10 hydrazine–hydrazine nitrate–water mixture. A definite gas evolution and a salt formation were noted after a few hours of contact.

It is believed that the recommendations given in the evaluation of copper (Sec. IV-A-4) are applicable to brass.

Experimental Data

Material tested: Commercial brass
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: Ambient
Time: A few hours
Results: A definite evolution of gas and a salt formation at the vapor–liquid interface were observed.

Material tested: Brass
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results No change in the specimen was noted.

Material tested: Brass
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 3.5% hydrazine decomposition was noted.

Material tested: Brass
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 30 days
Results: Approximately 4.5% hydrazine decomposition was observed (about the same decomposition as that noted in the blank run in glass).

Material tested: Brass
Source of data: Ref. 6
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 4 mo
Results: The sample was unaffected and did not decompose the hydrazine to any extent.

3. *Cobalt.* The available compatibility-test data indicate that cobalt is completely unsatisfactory for use with hydrazine nitrate mixtures. No experimental data relating to the compatibility of cobalt with pure hydrazine are available. However, it is known that metallic cobalt in finely divided form will catalyze the decomposition of hydrazine (Ref. 1). In addition, where hydrazine has been subjected to some salt or acid contamination, it has been found that cobaltic ions are capable of oxidizing hydrazine (Ref. 14). The compatibility of cobalt in sheet form has not been determined, and it may well be that the catalytic effect is reduced to a point where the material may have some degree of acceptability. In the absence of specific test data, however, it is believed that cobalt should be avoided.

Experimental Data

Material tested: Cobalt
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: Ambient
Time: A few hours

Results: A definite evolution of gas and a salt formation were noted.

4. Copper. It is recommended that copper be avoided for use with both hydrazine and hydrazine nitrate mixtures.

It is well-known that copper oxide, like iron oxide, is readily reduced by hydrazine, and that this reaction can be extremely violent. Also, laboratory tests have been conducted which indicate that cupric ions in solution with hydrazine cause more-than-normal decomposition (Ref. 1). In other studies, it was found that traces of dissolved copper strongly catalyzed auto-oxidation of hydrazine in air. (These tests were conducted by Audrieth and Mohr and are mentioned in Ref. 1.)

The hazards involved in the use of copper as a general construction material are illustrated by the experience of Mathieson Chemical Corporation (Ref. 1). In 1947, on the basis of the experience in preliminary compatibility tests, copper was chosen for fabrication of a hydrazine flash-distillation unit. The choice appeared satisfactory for almost 2 yr. Oxide film and/or oxide-welding-slag inclusions, which were later recognized as decomposition catalysts, eventually caused an explosion in the copper still. Battelle Memorial Institute reports (Ref. 6) that copper equipment in the Fairmount Chemical Company plant was found to be unsatisfactory.

It appears that copper falls into the same category as mild steel or iron, in that it would be acceptable under controlled conditions where it is not allowed to become oxidized, and where there is no possibility of contamination of the hydrazine.

Experimental Data

Material tested: Copper
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: No change in the specimen was noted.

Material tested: Copper
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: Ambient
Time: A few hours
Results: A definite evolution of gas and a salt formation were present at the vapor–liquid interface.

Material tested: Copper
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 12 mo
Results: When checked each month, the sample showed a loss in weight. The test was discontinued during the twelfth month.

Material tested: Copper
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: 8 mo
Results: At the end of 8 mo, there was very heavy corrosion of the sample. The test was then discontinued.

Material tested: Copper
Source of data: Ref. 15
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 1% hydrazine decomposition was observed. At ambient temperatures, copper showed the lowest percentage of hydrazine decomposition of any material tested by Battelle.

Material tested: Copper
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 30 days
Results: Approximately 27% decomposition of the hydrazine was noted. At 140°F, copper was the worst of all materials tested by Battelle.

Material tested: Inconel
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 2% hydrazine decomposition was noted (about ½% more than that for the blank run in glass).

5. Inconel. The available test data indicate that insignificant corrosion of Inconel occurs after contact with anhydrous hydrazine for time periods of at least a month. Since the principal constituent of Inconel is nickel, it is believed that the evaluation given for nickel (Sec. IV-A-13) should be referred to, and that the same precautions should be observed as those taken with pure nickel.

Inasmuch as no data are available with regard to the compatibility of Inconel with hydrazine nitrate mixtures, and in view of the limited corrosion resistance exhibited by nickel in contact with hydrazine nitrate mixtures, it is believed that contact with the nitrate mixtures should be avoided unless specific screening tests are undertaken.

Experimental Data

Material tested: Inconel (81% Ni, 13% Cr, 6% Fe)
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Sheet, 50 cm²
Propellant: Anhydrous hydrazine (95.09%)
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 77°F)
Time: 120 hr
Results: Negligible corrosion was noted.

Material tested: Inconel
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: No change in the sample was observed.

6. Inconel X. Only limited test data are available for Inconel X. Consequently, it is believed that the evaluation given for Inconel (Sec. IV-A-5) should be followed until additional data are available.

Experimental Data

Material tested: Inconel X (0.05% Cb, 0.49% Mn, 0.59% Si, 74.04% Ni, 14.24% Cu, 6.80% Fe, 2.20% Ti)
Source of data: Ref. 3
Number of samples tested: 1
Propellant: Hydrazine hydrate (66% N_2H_4)
Pressure: Atmospheric
Temperature: 13 to 23°C (56 to 73°F)
Time: 67.5 hr
Results: No evidence of corrosion was found.

7. Iron. All forms of iron are considered to be completely unsatisfactory for use with hydrazine or hydrazine nitrate mixtures.

It is well-known (Refs. 1 and 14) that iron oxide is readily reduced by hydrazine, and that this reduction, being exothermic, can become explosive under certain conditions. In addition to the hazards encountered with iron oxide, it has been found that metallic iron in finely divided form, and also ferric ions, markedly catalyze the decomposition of hydrazine. Since the general corrosion resistance of iron is poor, any salt or acid contamination of hydrazine would cause the introduction of iron impurities into the hydrazine.

If contact with oxygen and contamination of hydrazine could be completely avoided, iron would probably perform as a satisfactory material.

Experimental Data

Material tested: Cast iron
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: Ambient
Time: A few hours
Results: The solution had a cleaning effect on the surface, and gas evolution was noted. Use of this material is not recommended.

Material tested: Armco iron
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: Ambient
Time: A few hours
Results: Salt formation and gas evolution were noted.

Material tested: Electrolytic iron
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: Ambient
Time: A few hours
Results: Definite evolution of gas and salt formation were observed.

Material tested: Wrought iron
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: Ambient
Time: A few hours
Results: A reaction on the surface and definite gas evolution were noted.

Material tested: Soft iron
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 9 mo
Results: A considerable weight loss was noted each month. Very heavy corrosion and pitting were observed in the eighth month. The corrosion and pitting were so severe by the ninth month that the test was discontinued.

Material tested: Soft iron
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: 10 mo
Results: A weight loss was noted by the fifth month and each month thereafter. By the tenth month, the very heavy corrosion forced an end to the test.

Material tested: Pure iron
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 2.5% hydrazine decomposition was observed, and a pressure increase of 50 mm Hg occurred. This material is considered unsatisfactory for use with hydrazine.

Material tested: Pure iron
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 30 days
Results: Approximately 2.0% hydrazine decomposition was noted (a blank run in glass showed 4.5% decomposition). A pressure increase of 100 mm

Hg occurred. This material is considered unsatisfacto y for use with hydrazine.

8. Lead. All t ıe compatibility-test data available, with the exception of findings in a test made by NACA, indicate virtually immediate reaction with lead in contact with either anhydrous hydrazine or hydrazine nitrate mixtures. In view of the obvious high rate of corrosion, lead is considered to be completely unsatisfactory for use with hydrazine or hydrazine nitrate mixtures.

Experimental Data

Material tested: Lead
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: A definite reaction was observed, with a yellow salt formation and loss of weight in the specimen.

Material tested: Lead
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: No change was noted in the specimen.

Material tested: Lead
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 22 hr
Results: The sample reacted immediately, and severe corrosion was apparent in 22 hr. The test was discontinued.

Material tested: Lead
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: Minutes
Results: The sample reacted immediately, and the solution turned blue. The test was discontinued.

9. Magnesium. Magnesium is considered to be completely unsatisfactory for use with anhydrous hydrazine. All organizations that have undertaken compatibility tests have observed an almost immediate reaction, resulting in the evolution of large volumes of gas and severe corrosion of the magnesium. No experimental data are available on the compatibility of magnesium with hydrazine hydrate; it seems likely, however, that such data would also be unsatisfactory.

Only one test with hydrazine nitrate mixtures is reported. Some reaction was noted, apparently severe enough to warrant abandonment of further testing. On the basis of this test it appears that magnesium is unsuitable for use with hydrazine nitrate mixtures.

Experimental Data

Material tested: Magnesium
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 24 hr
Results: The sample lost weight so rapidly that the test was discontinued after 24 hr.

Material tested: Magnesium
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Sheet
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: Minutes

Results: A reaction occurred immediately, giving off hydrogen. The test was discontinued.

Material tested: Magnesium alloy M-1
Source of data: Ref. 16
Number of samples tested: 6
Shape of samples: ⅛-in. sheet
Propellant: Anhydrous hydrazine (96%)
Pressure: Atmospheric
Temperature: Ambient
Time: 24 hr
Results: All the samples were withdrawn after 24 hr. The samples were pitted, and a heavy white precipitation appeared in the solution.

Material tested: Magnesium
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 1.25% hydrazine decomposition was indicated by chemical analysis; however, a pressure increase of 474 mm Hg was noted. Magnesium is not considered satisfactory for use with hydrazine.

Material tested: Magnesium
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Strip
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: No weight change was observed in the sample; however, gas evolution and surface blackening were noted. The material was not considered promising enough to warrant further testing.

10. Manganese. Only one test on the compatibility of manganese with hydrazine has been reported. This test was made with a 45% hydrazine–45% hydrazine nitrate–10% water mixture. Excessive gas formation was noted almost immediately, and the test was discontinued after a few hours. The compatibility of manganese with hydrazine nitrate solutions is considered to be unsatisfactory.

In view of the meager data, it is believed that testing with anhydrous hydrazine should be undertaken before a firm conclusion is drawn. For the present, in the absence of specific testing, it is believed that the use of manganese should be avoided.

Experimental Data

Material tested: Manganese
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Strip
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: Ambient
Time: A few hours
Results: An obvious reaction, with excessive gas formation, was noted, and the test was discontinued. This material is considered unsatisfactory for use with hydrazine.

11. Molybdenum Molybdenum is considered to be completely unacceptable for use with hydrazine or hydrazine nitrate mixtures.

From the standpoint of corrosion, molybdenum appears to possess limited suitability with hydrazine; however, it is known that molybdenum strongly catalyzes the decomposition of liquid hydrazine and, for this reason, is unacceptable. Molybdenum has been found to catalyze hydrazine decomposition when present in a finely divided metallic form. In addition, it is known that, under suitable conditions, hydrazine enters spontaneously into a combustion reaction with oxidized molybdenum (MoO_3) (Ref. 1). Apparently, even small quantities of molybdenum in various alloys are sufficient to produce a marked increase in the decomposition of hydrazine. A series of vapor-phase decomposition tests was made by Olin Industries (Ref. 1), in which various metals were exposed in the vapor phase of refluxing hydrazine. The tests with 316 stainless steel (4% Mo) and with Hastelloy A (70% Ni, 30% Mo) yielded appreciably larger pressure rises than those observed with 304 stainless steel and nickel. Over a time period of 14.5 hr, the pressure rise for 304 stainless was 31 mm Hg; for 316 stainless, it was 194 mm Hg; and, for pure nickel, it was 79 mm Hg. For Hastelloy A, the pressure rise was 198 mm Hg in only 2 hr.

Experimental Data

Material tested: Molybdenum (sintered, swaged, and rolled by Westinghouse)
Source of data: Ref. 3
Number of samples tested: 2
Shape of samples: Disk cut from sintered bar
Propellant: Anhydrous hydrazine (95.09%)
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 75°F)
Time: 120 hr
Results: Penetration of the samples was negligible.

Material tested: Molybdenum (sheet, plated with 0.004-in. chrome)
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Sheet
Propellant: Anhydrous hydrazine (93.23%)
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 75°F)
Time: 169 hr
Results: No change in the weight of the sample was observed.

Material tested: Molybdenum
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: Ambient
Time: A very short time
Results: Gas evolution occurred upon contact of the sample with the solution. Testing was immediately discontinued.

Material tested: Molybdenum
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 1.5% hydrazine decomposition was noted.

12. *Monel.* The available test data concerning Monel in contact with anhydrous hydrazine indicate negligible corrosion for a time period of approximately 1 mo. Monel does not appear suitable for use with hydrazine nitrate mixtures.

More important than the corrosion aspects, however, is the fact that Monel is composed of 67% Ni, 30% Cu, 1% Fe, 1% Mn. All these elements, in either ionic or finely divided form, have been observed to be catalytic in the decomposition of hydrazine. For specific information, the reader is referred to the recommendations given for each of these metals elsewhere in this Memorandum.

It is therefore believed that Monel should be avoided for general use with hydrazine and should not be used at all with the nitrate mixtures. If, for some reason, the use of Monel is particularly desired, care should be taken to assure that the hydrazine is uncontaminated, that oxidation conditions are not present, and that contact time is limited.

Experimental Data

Material tested: Monel (67% Ni, 30% Cu, 1% Fe, 1% Mn)
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Rolled sheet
Propellant: Anhydrous hydrazine (97.63%)
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 75°F)
Time: 92 hr
Results: A penetration of 0.00011 in./yr was recorded. A very light attack on the surface of the sample was noted.

Material tested: Monel
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: Less than 7 days

Results: The sample was removed from the oven after salt formation was observed in the solution.

Material tested: Monel
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Sheet
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: No change in the specimen was observed.

Material tested: Monel
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 1.5% hydrazine decomposition was recorded (slightly more than that noted in the blank run in glass).

13. Nickel. From the standpoint of corrosion, nickel appears to be relatively unaffected by contact with anhydrous hydrazine for periods of 1 to 2 mo. The only test data for hydrazine nitrate mixtures indicate that a reaction occurred after several hours at 165°F.

Nickel in finely divided form (Raney Nickel) has been observed to catalyze hydrazine decomposition. Here again, as with stainless steel, cobalt, etc., the controlling factor appears to be the extended surface area (Ref. 2). Ions of nickel have been found to be noncatalytic in pure hydrazine (Ref. 1); however, where the hydrazine has been contaminated (with some acidic or basic substance), and hydrazine salts are present, catalytic decomposition of the hydrazine may occur (Ref. 2).

Therefore, nickel should be avoided for use with hydrazine where intermittent atmospheric contact may occur, or where impure hydrazine is likely to be present. Where adequate precautions are taken, nickel appears to be suitable for limited time periods. The use of nickel with hydrazine nitrate mixtures is not recommended.

Experimental Data

Material tested: Commercially pure nickel
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Rolled sheet
Propellant: Anhydrous hydrazine (97.63%)
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 75°F)
Time: 92 hr
Results: No evidence of corrosion was found.

Material tested: Nickel
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: No change in the specimen was observed.

Material tested: Nickel
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 74°C (165°F)
Time: 24 hr
Results: Salt formation became apparent after a short period of time. The specimen was removed from the oven, and the test was discontinued.

Material tested: Nickel
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 12 mo
Results: A weight loss in the sample was noted each month.

Material tested: Nickel
Source of data: Ref. 9
Number of samples tested: 1

Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 65°C (165°F)
Time: 10 mo
Results: A weight loss was noted during the fifth month and each month thereafter. By the tenth month, the very heavy corrosion necessitated discontinuing the test.

Material tested: Nickel
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 1% hydrazine decomposition was noted.

Material tested: Nickel
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 30 days
Results: Approximately 24% hydrazine decomposition was observed (about 6 times the value for the blank run in glass).

Material tested: A-Nickel (99.4% Ni + Co)
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 2.25% hydrazine decomposition was found (a blank run in glass showed 1.5% decomposition).

14. Nickel–chromium alloys. The only available data were obtained from tests made with a nickel–chromium alloy in contact with a hydrazine nitrate mixture. Because of the scarcity of data, and also because of the similarity of this alloy to pure nickel, it is believed that, at least for the present, the evaluation given for nickel should be followed.

Experimental Data

Material tested: Nickel–chromium alloy (75% Ni, 12% Cr, 9% Fe, 5% Cu)
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 74°C (165°F)
Time: 24 hr
Results: Formation of salt in the solution was noted after a short period of time. The sample was removed from the oven, and the test was discontinued.

Material tested: Nickel–chromium alloy (Nichrome, 61% Ni, 15% Cr, balance Fe)
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 1.5% hydrazine decomposition was observed (a slightly higher decomposition than that noted in the blank run in glass).

Material tested: Nickel-chromium alloy (Chromel-A)
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 3% hydrazine decomposition was recorded (about twice that obtained with the blank run in glass).

15. Silver. Only one source of data has been found relating to the compatibility of silver with anhydrous hydrazine. From these data, silver appears to be suitable, from a corrosion standpoint, for use with hydrazine for at least a month. However, Mathieson Chemical Corporation reports (Ref. 1) that hydrazine is capable of reducing the salts and oxides of silver, with a possible acceleration of the decomposition of the hydrazine. For this reason, silver should be avoided for general use.

Experimental Data

Material tested: Silver
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 2% hydrazine decomposition was observed (about ½% more than that obtained in the blank run in glass).

16. Steel (mild). Mild steel of any type is considered to be undesirable for contact with hydrazine or hydrazine nitrate mixtures.

From a corrosion standpoint, the available test data indicate that, in general, there is negligible corrosion of mild steel in contact with anhydrous hydrazine for time periods of approximately 1 mo. After more extended periods, the corrosion and weight loss are more severe.

Corrosive attack by hydrazine nitrate mixtures appears to be much more rapid; however, the primary danger in using mild steel is the possible formation of rust, which can react with the hydrazine.

For additional details, see the evaluation of iron (Sec. IV-A-7). If, for some specific reason, mild steel must be used, extreme care should be taken to keep the surface free of oxides.

Experimental Data

Material tested: Mild steel (SAE 1020)
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Rolled sheet
Propellant: Anhydrous hydrazine (97.63%)
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 75°F)
Time: 92 hr
Results: Any visible corrosion was masked by rust formed after the test. Although the test results indicate negligible corrosion of the steel, this material is not recommended for use because of the ease of rusting and the effect of rust on the decomposition of hydrazine.

Material tested: Spring steel
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: Definite salt formation and loss of weight (4.45%) in the sample were observed.

Material tested: M-grade steel
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: Definite loss in sample weight (9.04%) and formation of gray salt in the solution were noted.

Material tested: Steel (SAE 4130, annealed)
Source of data: Ref. 16
Number of samples tested: 3
Shape of samples: ⅛-in. sheet
Propellant: Anhydrous hydrazine (96%)
Pressure: Atmospheric
Temperature: Ambient
Time: 36 to 278 days
Results: Some loss in weight was noted for all samples. This material is not recommended because of rust possibilities.

Material tested: Cold-rolled steel
Source of data: Ref. 4

Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: No change in the specimen was observed.

Material tested: Mild steel
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 12 mo
Results: A weight loss was noted each month when the sample was checked. By the seventh month, considerable corrosion was apparent.

Material tested: Mild steel
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: 10 mo
Results: A weight loss in the sample was noted, starting at the fifth month. The test was discontinued in the tenth month, when very heavy corrosion was found to be present.

Material tested: Mild steel
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 2.0% hydrazine decomposition was observed (about ½ more than that for the blank run in glass). A significant pressure increase was noted.

Material tested: Mild steel
Source of data: Ref. 6
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 4 mo
Results: The sample was unaffected and did not decompose the hydrazine.

17. Steel (stainless). The compatibility of stainless steel with anhydrous hydrazine has been investigated rather thoroughly. However, because of the wide variety of stainless steels available, it is necessary that recommendations for each type be given separately.

Of the stainless steels which have been tested, only two are presently considered suitable for unlimited service types 304 and 347. This recommendation is based on (1) the data presented below, (2) the successful application of such steels in test-cell installations at this Laboratory for over 8 yr, and (3) the recommendations of Mathieson Chemical Corporation (Refs. 1 and 2) and Fairmount Chemical Company (Ref. 6), after years of successful service in the production and storage of hydrazine.

The suitability of these stainless steels appears paradoxical, on cursory examination, in view of the known fact that ferric ions, as well as iron and stainless steels in finely divided form, are catalytic in the decomposition of hydrazine. Practically, of course, the stainless steel is present in sheet or plate form and has a relatively smooth surface, so that the extended surface area is minimized. In addition, large quantities of metallic ions will not be present unless there has been salt or acid contamination of the metal surface, accompanied by the usual metallic corrosion and introduction of ions into the solution. There is little possibility of the occurrence of this problem, because of the excellent resistance of 304 and 347 stainless steel to such acid attack.

Molybdenum has been observed to be a particularly potent catalyst in the decomposition of liquid hydrazine (Ref. 1). Consequently, molybdenum-stabilized stainless steels (the most common being type 316) should be avoided. There is insufficient evidence, at present, to warrant setting a maximum allowable tolerance for molybdenum in stainless steels; therefore, it is believed that types 303, 315, 317, 318, 329, 416, 420F, 430F, 440A, and 440C should be avoided, until sufficient data are available to permit some definite conclusions to be drawn.

It is believed that other 300-series steels, such as 302 and 321, may also be suitable for unlimited service, but that, in the absence of adequate experimental data, their use should be restricted to moderate time periods.

Other 400-series steels, such as 410 and 430, also fall into this category; however, the additional factor of their poorer resistance to rusting should be taken into consideration.

Experimental data concerning the compatibility of stainless steels with hydrazine nitrate mixtures are meager. The Naval Ordnance Laboratory noted salt formation and weight loss with 18-8 stainless steel (type not given) in contact with a mixture of 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O for 7 days at 165°F. This Laboratory, however, has utilized types 304 and 347 stainless steels for test-cell equipment for 2 to 3 yr, in contact with a 66% N_2H_4–24% $N_2H_5NO_3$–10% H_2O mixture, with no apparent difficulties. It is considered necessary that additional tests be made before any specific conclusions with regard to the hydrazine nitrate mixtures can be drawn.

Where stainless steels are joined, heliarc welding should be used to eliminate slag or oxide inclusions which may act to catalyze the decomposition of hydrazine.

Experimental Data

Material tested: Type 304 stainless steel [0.08% C (max), 17.5/19% Cr, 8/9% Ni, solution heat-treated]
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Solid cylinder
Propellant: Hydrazine hydrate (66%)
Pressure: Atmospheric
Temperature: 14 to 25°C (59 to 75°F)
Time: 67.5 hr
Results: No corrosion was apparent, and no change occurred in the weight of the sample.

Material tested: Type 304 stainless steel
Source of data: Ref. 16
Number of samples tested: 6
Shape of samples: ⅛-in. sheet
Propellant: Anhydrous hydrazine (96%)
Pressure: Atmospheric
Temperature: Ambient
Time: 119 to 382 days
Results: A slight loss in weight was observed for all samples.

Material tested: Type 302 stainless steel
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: No change in the specimen was found after the test. A pressure increase due to gas evolution was recorded, equal to 0.015 atm/day/ml N_2H_4.

Material tested: Type 321 stainless steel
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: No change was observed in the specimen. The pressure increase due to gas evolution was 0.011 atm/day/ml N_2H_4.

Material tested. Type 430 stainless steel
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: No change was observed in the specimen. The pressure increase due to gas evolution was 0.010 atm/day/ml N_2H_4.

Material tested: Stainless W alloy (Carnegie-Illinois: 0.06% C, 7% Ni, 17% Cr, 0.6% Ti, 0.2% Al)
Source of data: Ref. 3
Number of samples tested: 2
Shape of samples: Disk from bar stock

Propellant: Anhydrous hydrazine (93.23%)
Pressure: Atmospheric
Temperature: 24°C (75°F)
Time: 147 hr
Results: No corrosion or change in weight was noted in either sample.

Material tested: Stainless steel (type not specified)
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 12 mo
Results: A weight loss was noted each month. The material was not considered satisfactory.

Material tested: Stainless steel (type not specified)
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: 12 mo
Results: A weight loss was noted in the sample at the fifth month and each month thereafter.

Material tested: Type 347 stainless steel
Source of data: Ref. 17
Number of samples tested: 4
Shape of samples: Lathe turnings from bar stock
Propellant: Anhydrous hydrazine (95.33%)
Pressure: Closed system, initially atmospheric
Temperature: Ambient
Time: 39 days
Results: The four samples were actually tested as follows: two samples were stored in the daylight; one was stored in the dark; the remaining one was preheated to 500°C for 15 min, cooled, and immersed in the hydrazine. None of the samples showed any visible signs of rusting or corrosion at any time, nor did they show any appreciable change in weight after 39 days of exposure. The change in hydrazine concentration noted during the tests was not significant (0.5% or less); however, it was concluded that hydrazine stored in daylight decomposes slowly, as compared with material stored in the dark, and that the presence of stainless steel has a slight accelerating effect on the decomposition in daylight.

Material tested: Type 304 stainless steel
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 1.25% hydrazine decomposition was observed (slightly lower than the decomposition noted in the blank run in glass).

Material tested: Type 304 stainless steel
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 30 days
Results: Approximately 4% hydrazine decomposition was noted (about ½% less than that noted in the blank run in glass).

Material tested: Type 317 stainless steel
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 1.5% hydrazine decomposition was observed (about the same as that noted in the blank run in glass).

Material tested: Type 302 stainless steel
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)

Time: 30 days
Results: Approximately 2% hydrazine decomposition was noted (about ½% more than that noted in the blank run in glass).

Material tested: 12%-chromium stainless steel
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 1.5% hydrazine decomposition was observed (about the same as that noted in the blank run in glass).

Material tested: Type 304 stainless steel
Source of data: Ref. 6
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 4 mo
Results: The sample was unaffected and did not decompose the hydrazine to any extent.

Material tested: Type 18-8 stainless steel
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Strip
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: Definite salt formation occurred in the liquid phase, and corrosion was noted in both the liquid and the vapor phase. The weight loss of the sample was 0.23%.

18. Stellite. The results of a single investigation, consisting of a 67½-hr corrosion test with hydrazine hydrate, are the only data available. From a corrosion standpoint, the stellite appeared to be unaffected. However, because of the high percentage of molybdenum present (4.5 to 6.5%), which has been observed (Ref. 1) to be a specific and potent catalyst for the decomposition of liquid hydrazine, it is believed that stellite should be avoided for contact with anhydrous hydrazine, hydrazine hydrate, and hydrazine nitrate mixtures.

Experimental Data

Material tested: Stellite 21 (0.20/0.35% C, 25/30% Cr, 1.75/3.75% Ni, 4.5/6.5% Mo, 2.0% max Fe, balance Co)
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Cast section of blade
Propellant: Hydrazine hydrate (66%)
Pressure: Atmospheric
Temperature: 14 to 25°C (59 to 75°F)
Time: 67.5 hr
Results: No evidence of corrosion was found.

19. Tantalum. Two organizations have conducted compatibility tests of tantalum in contact with anhydrous hydrazine. Both tests, one continuing for approximately a month and the other for almost a year, were carried out at ambient temperatures and indicate that the tantalum was unaffected and caused no significant decomposition of the hydrazine. In view of the limited data, it is concluded that additional testing under elevated-temperature conditions should be undertaken before tantalum can be considered acceptable for unlimited service. No test data regarding the compatibility of tantalum with hydrazine hydrate or hydrazine nitrate mixtures are available.

Experimental Data

Material tested: Tantalum
Source of data: Ref. 10
Number of samples tested: 1
Shape of sample: Sheet, 10 mm × 100 mm × 37 mm
Propellant: Anhydrous hydrazine (97.5%)
Pressure: Closed system, initially atmospheric
Temperature: Ambient
Time: 331 days
Results: The sample was completely unaffected. No significant decomposition of the hydrazine was noted.

Material tested: Tantalum
Source of data: Ref. 6

Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 2% hydrazine decomposition was noted (about ½% higher than that found in the blank run in glass).

20. Tin. It would appear that, from a corrosion standpoint, tin can be considered acceptable over a narrow range of temperatures. Picatinny Arsenal noted no change in the weight of a tin sample in contact with hydrazine at room temperature for 12 mo, but observed weight and surface discoloration after contact for approximately 6 mo at 149°F. Battelle Memorial Institute does not make note of any corrosion after contact for 1 mo at either 80°F or 140°F.

More important, perhaps, than the corrosion aspects of tin compatibility is the fact that the contamination of liquid hydrazine by the oxides of tin lower the ignition temperature in air from 428°F to 230°F (Ref. 9). For this reason, tin is not recommended for general use with anhydrous hydrazine or hydrazine nitrate mixtures.

Experimental Data

Material tested: Tin
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 12 mo
Results: No change in the weight of the sample was noted.

Material tested: Tin
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: 11 mo
Results: A loss in the weight of the sample was noted, starting with the seventh month. By the eleventh month, the metal had turned very dark, and the test was discontinued

Material tested: Tin
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples. Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 3% hydrazine decomposition was noted (a blank run in glass showed 1.5% decomposition).

Material tested: Tin
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 30 days
Results: Approximately 4% hydrazine decomposition was observed (about the same decomposition as that noted in the blank run in glass).

21. Titanium. Titanium is considered completely satisfactory for use with anhydrous hydrazine or hydrazine nitrate mixtures. Although only one organization, the U.S. Naval Ordnance Laboratory, has undertaken a compatibility test program, this program was detailed and conclusive. Aspects of material corrosion, as well as solution stability, were determined at ambient and elevated temperatures (160°F) with anhydrous hydrazine and with a number of hydrazine nitrate mixtures of varying concentration. In all cases, the test samples were entirely unaffected, and the solutions themselves showed no significant decomposition.

Experimental Data

Material tested: Titanium
Source of data: Ref. 5
Number of samples tested: 4

Shape of samples: Sheet, 10 mm × 100 mm × 3 mm
Propellants: 97.5% N_2H_4–1.9% H_2O–0.6% NH_3
78.4% N_2H_4–18.1% $N_2H_5NO_3$–3% H_2O–0.5% NH_3
44.9% N_2H_4–45.3% $N_2H_5NO_3$–9.4% H_2O–0.4% NH_3
19.6% N_2H_4–78.4% $N_2H_5NO_3$–1.8% H_2O–0.2% NH_3
Pressure: Closed system, initially atmospheric
Temperature: Ambient
Time: 324 to 355 days
Results: The material was entirely unaffected. No significant decomposition was observed in any of the solutions.

Material tested: Titanium
Source of data: Ref. 8
Number of samples tested: 1
Shape of sample: Strip
Propellant: 70% N_2H_4–25% $N_2H_5NO_3$–5% H_2O
Pressure: Closed system, initially atmospheric
Temperature: 71°C (160°F)
Time: 9 wk
Results: The titanium strip was completely unaffected. No significant change in solution composition had taken place.

22. *Zinc.* All experimental data available indicate that zinc is completely unsatisfactory for contact with anhydrous hydrazine or hydrazine nitrate mixtures. A definite reaction takes place quickly, with severe corrosion of the metal and the formation of a precipitate.

Experimental Data

Material tested: Zinc
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: Ambient
Time: 24 hr
Results: A definite reaction was noted, with complete decomposition of the sample at room temperature. The specimen was not tested at 74°C because of its reactivity.

Material tested: Zinc
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 2 mo
Results: Very heavy corrosion was apparent after 1 mo. There was a deposit of hygroscopic crystalline material over the entire strip. The sample was cleaned and placed in the solution for another month. At the end of the second month, the same condition was apparent. The test was discontinued.

Material tested: Zinc
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: 8 mo
Results: A weight loss was noted after 1 mo. By the eighth month of the test, very heavy corrosion and incrustation of the metal was apparent. The test was discontinued.

B. Plastics and Elastomers

1. *Cellulose acetate.* Cellulose acetate appears to be completely unsuitable for contact with hydrazine–hydrazine nitrate–water mixtures. No data on its compatibility with anhydrous hydrazine are available. If the material is required for application with anhydrous hydrazine, additional tests should be undertaken. In the absence of experimental data with anhydrous hydrazine, this material is not recommended.

Experimental Data

Material tested: Cellulose acetate (flow F-8)
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric

Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: This material, when placed in the propellant, became swollen and showed definite signs of chemical decomposition. The same type of reaction occurred at ambient temperature and at 74°C.

2. *Diallyl phthalate.* This material appears to be completely unsuitable for contact with hydrazine–hydrazine nitrate–water mixtures. No test data concerning its compatibility with anhydrous hydrazine are available; however, because of its extremely poor behavior with the nitrate mixture, it would also be unsatisfactory with anhydrous hydrazine.

Experimental Data

Material tested: Diallyl phthalate (Shell)
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: The sample was completely decomposed by the solution.

3. *Epon.* Epon is not recommended for contact with hydrazine nitrate mixtures for extended periods of time. Contact times should probably be limited to a few weeks. No experimental data on the use of this material with anhydrous hydrazine are available; however, it appears probable that Epon would also be acceptable in this application for short contact times.

Experimental Data

Material tested: Epon
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: The specimens showed a definite gain in weight and appeared bleached.

4. *Ethyl cellulose.* Ethyl cellulose appears to have been dissolved to some extent by a hydrazine nitrate mixture. In view of the degree of attack, ethyl cellulose would probably be acceptable for time periods of a few weeks, both in hydrazine nitrate mixtures and in anhydrous hydrazine.

Experimental Data

Material tested: Ethyl cellulose (E/C-232)
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: An apparent material loss of 2% and a very slight color change were noted.

5. *Furane resin.* It appears that furane is soluble to some extent in hydrazine nitrate mixtures. In all likelihood, furane resin would be acceptable in contact with hydrazine nitrate mixtures and anhydrous hydrazine for time periods limited to a few weeks.

Experimental Data

Material tested: Furane resin (Resin X)
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: The sample showed a definite loss in weight (4.3%). No other physical changes were noted.

6. *Hycar.* The only experimental data available indicate limited acceptability for Hycar in contact with hydrazine hydrate. It is probable that it would also be acceptable with anhydrous hydrazine for short-term contact. Additional tests should be made before use with hydrazine nitrate mixtures is contemplated.

Experimental Data

Material tested: Hycar
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: O-ring
Propellant: Hydrazine hydrate
Pressure: Atmospheric
Temperature: 14 to 25°C (59 to 75°F)
Time: 67.5 hr
Results: A slight reduction in the weight of the sample was observed. This material was considered satisfactory by M. W. Kellogg Company.

7. ***Kel-F.*** Kel-F appears to be satisfactory for extended use with both hydrazine and hydrazine nitrate mixtures. Experimental data indicate surface discoloration, but no apparent effect on other physical properties. It is believed, however, that if there is any preference in the use of plastics, Teflon or polyethelene should be employed before Kel-F is considered.

Experimental Data

Material tested: Kel-F (NST 270, pressed)
Source of data: Ref. 16
Number of samples tested: 6
Shape of samples: ⅛-in. sheet
Propellant: Anhydrous hydrazine (96%)
Pressure: Atmospheric
Temperature: Ambient
Time: 114 to 377 days
Results: Most samples showed very slight weight increases. Two samples were tinted brown. One sample, at the end of 377 days, showed no weight change.

Material tested: Kel-F
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: No sign of definite loss or gain in weight was noted. The specimen turned brown (apparently, a skin effect).

Material tested: Kel-F
Source of data: Ref. 18
Test conditions: None given
Results: This material is considered by North American Aviation, Inc., to be suitable in contact with hydrazine for extended times at temperatures up to 390°F.

8. ***Lactopreme.*** This material apparently changes physical properties rather drastically on contact with hydrazine nitrate mixtures. It is likely that it would also be unsatisfactory for use with anhydrous hydrazine.

Experimental Data

Material tested: Lactopreme (BN-15-298)
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: The specimens showed a slight loss in weight. The material cracked, became embrittled, and showed a color change.

9. ***Lucite.*** Lucite appears to be satisfactory for contact periods of a few weeks, both with anhydrous hydrazine and with hydrazine nitrate mixtures.

Experimental Data

Material tested: Lucite (Methacrylate, Dupont)
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric

Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: The samples showed a slight loss in weight, but no apparent physical changes were noted.

Material tested: Lucite
Source of data: Ref. 6
Number of samples tested: 1 or 2
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 29°C (85°F)
Time: 30 days
Results: Approximately 3% hydrazine decomposition was observed (about twice that noted in the blank run in glass).

10. Melamine formaldehyde. Melamine formaldehyde was affected to some extent by the hydrazine nitrate mixture used in the test. It probably would be acceptable in contact with hydrazine nitrate mixtures or anhydrous hydrazine for terms limited to approximately a week.

Experimental Data

Material tested: Melamine formaldehyde (Melmac 1500)
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: The samples showed a definite loss in weight (3.12%). A bleaching effect was noted in both the liquid and the vapor phase.

11. Nylon. Nylon appears to possess limited acceptability for use with anhydrous hydrazine or hydrazine nitrate solutions. It apparently would be usable for short-term contact, but not for extended application.

Experimental Data

Material tested: Nylon (10001)
Source of data: Ref. 5
Number of samples tested: 4
Shape of samples: Sheet
Propellants: 97.5% N_2H_4–1.9% H_2O–0.6% NH_3
78.4% N_2H_4–18.1% $N_2H_5NO_3$–3% H_2O–0.5% NH
44.9% N_2H_4–45.3% $N_2H_5NO_3$–9.4% H_2O–0.4% NH_3
19.6% N_2H_4–78.4% $N_2H_5NO_3$–18% H_2O–0.2% NH_3
Pressure: Atmospheric
Temperature: Ambient
Time: 167 to 382 days
Results: The samples varied, but all showed yellowing and brittleness. The worst samples exhibited a roughened and powdery surface.

12. Phenolic. This material would probably be suitable for contact with both the hydrazine nitrate mixtures and anhydrous hydrazine for times limited to a few days. However, because of its definite chemical breakdown, it should be avoided if possible.

Experimental Data

Material tested: Phenolic (BN-250)
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: The loss in weight of the sample was slight, but the surface of the material showed definite signs of chemical reaction.

13. Polyester. Polyester appeared to be rather readily attacked by the hydrazine nitrate test mixture and, consequently, is not recommended for use with hydrazine nitrate mixtures. In all likelihood, it would behave comparably in anhydrous hydrazine.

Experimental Data

Materials tested: (1) Polyester (500)
(2) Polyester (P-43/Styrene, 5% Al, 2% Co)

Source of data: Ref. 10
Number of samples: 2 each
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: A slight loss in weight, a definite color change, and decomposition of the material was noted in all cases. A pungent gas was noted during and after removal of the samples from the oven.

14. Polyethylene. Polyethylene appears to be well suited for use with anhydrous hydrazine or hydrazine nitrate mixtures. All experimental data indicate no change in the physical condition of the polyethylene for time periods of somewhat more than 1 yr, at both ambient and elevated temperatures.

Experimental Data

Material tested: Polyethylene
Source of data: Ref. 5
Number of samples tested: 4
Shape of samples: Sheet
Propellants: 97.5% N_2H_4–1.9% H_2O–0.6% NH_3
78.4% N_2H_4–18.1% $N_2H_5NO_3$–3% H_2O–0.5% NH_3
44.9% N_2H_4–45.3% $N_2H_5NO_3$–1.8% H_2O–0.4% NH_3
19.6% N_2H_4–78.4% $N_2H_5NO_3$–9.4% H_2O–0.2% NH_3
Temperature: Ambient
Time: 312 to 383 days
Results: The samples were apparently unaffected.

Material tested: Polyethylene
Source of data: Ref. 8
Number of samples tested: 1
Shape of sample: Sheet
Propellant: 70% N_2H_4–25% $N_2H_5NO_3$–5% H_2O
Pressure: Atmospheric
Temperature: 71°C (160°F)
Time: 9 wk
Results: A very slight weight increase was observed, but no apparent change occurred in the physical condition of the specimen.

Material tested: Polyethylene
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 12 mo
Results: No loss or gain in the weight of the sample was observed. The material was completely satisfactory after contact with hydrazine for a period of 1 yr.

Material tested: Polyethylene
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: 12 mo
Results: No change occurred in the weight or appearance of the sample. The material was completely satisfactory after contact with hydrazine for period of 1 yr.

Material tested: Polyethylene
Source of data: Ref. 18
Experimental data: None given
Results: The material was considered by North American Aviation, Inc., to be suitable in contact with hydrazine for long-time service at temperatures up to 120°F

Material tested: Polyethylene
Source of data: Ref. 6
Number of samples tested: 1 or 2
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 2% hydrazine decomposition was observed (about ½% more than that noted for the blank run in glass).

15. Polystyrene and polydichlorostyrene. Both of these materials exhibited physical-property changes after contact with anhydrous hydrazine or hydrazine nitrate mixtures. Although they will probably stand up for short periods of time, their use is not recommended.

Experimental Data

Materials tested: (1) Polystyrene (Koppers)
(2) Polydichlorostyrene (Mathieson)
Source of data: Ref. 10
Number of samples tested: 1 each
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: Surface changes and warping were observed.

Material tested: Polystyrene
Source of data: Ref. 5
Number of samples tested: 4
Shape of samples: Sheet
Propellants: 97.5% N_2H_4–1.9% H_2O–0.6% NH_3
78.4% N_2H_4–18.1% $N_2H_5NO_3$–3% H_2O–0.5% NH_3
44.6% N_2H_4–45.3% $N_2H_5NO_3$–9.4% H_2O–0.4% NH_3
19.6% N_2H_4–78.4% $N_2H_5NO_3$–1.8% H_2O–0.2% NH_3
Pressure: Atmospheric
Temperature: Ambient
Time: 43 to 383 days
Results: All the samples exhibited large weight increases and internal frosting and cracking or caused gas evolution and solution-composition changes. The material is not recommended for long-term storage.

16. Polyvinyl alcohol. This material is completely unsatisfactory for use with anhydrous hydrazine. No data are available on its compatibility with hydrazine nitrate mixtures. However, it is probable that it would be equally unsatisfactory in the latter application.

Experimental Data

Material tested: Polyvinyl alcohol
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Sheet
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: ½ hr
Results: The material swelled and started to disintegrate in ½ hr.

Material tested: Polyvinyl alcohol
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Sheet
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: 1 hr
Results: The material swelled in 1 hr.

17. Polyvinyl chloride (Koroseal, Vinylite). The consensus among the organizations which have tested polyvinyl chloride is that this material is completely unsatisfactory for contact with hydrazine or hydrazine nitrate mixtures. All organizations, with one exception, report severe changes in the physical properties of the polyvinyl chloride within a short time.

Experimental Data

Material tested: Polyvinyl chloride (B. F Goodrich)
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: The samples showed definite weight gains and changes in physical properties. The material changed color, and the surface of the material cracked and blistered.

Material tested: Polyvinyl chloride (unplasticized)
Source of data: Ref. 8
Number of samples tested: 1
Shape of sample: Sheet
Propellant: 70% N_2H_4–25% $N_2H_5NO_3$–5% H_2O

Pressure: Atmospheric
Temperature: 71°C (160°F)
Time: 9 wk
Results: The specimens turned brown, swelled, and were extensively blistered. Needlelike crystals were obviously formed. The material is considered unsuited for use with hydrazine solutions.

Material tested: Polyvinyl chloride
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 7 days
Results: The material turned deep yellow in 7 days.

Material tested: Polyvinyl chloride
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: 2 days
Results: The material swelled, turned deep yellow, then became cream-colored in 2 days.

Material tested: Polyvinyl chloride (Koroseal, B. F. Goodrich)
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Sheet
Propellant: Hydrazine hydrate
Pressure: Atmospheric
Temperature: 14 to 25°C (59 to 75°F)
Time: 67.5 hr
Results: Small blisters on the sample were observed at the end of the test. However, M. W. Kellogg considered the material satisfactory.

Material tested: Polyvinyl chloride (Koroseal, B. F. Goodrich)
Source of data: Ref. 18
Test conditions: None given
Results: This material is considered by North American Aviation, Inc., to be suitable for long-time use at temperatures up to 122°F. Some swelling was noted at higher temperature (150°F).

Material tested: Polyvinyl chloride (Vinylite, Bakelite)
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: O-ring linear mold 3248C
Propellant: Anhydrous hydrazine (94.48%)
Pressure: Atmospheric
Temperature: 15.2 to 23°C (59 to 74°F)
Time: 48 hr
Results: The entire sample became darker. There was some loss of flexibility. The material was considered still usable at the end of the test.

*18. **Rubber (natural).*** The majority of the organizations which have tested natural rubber with anhydrous hydrazine report that the rubber absorbed hydrazine. It is believed that natural gum rubber should be avoided, if possible.

Experimental Data

Material tested: Natural gum rubber
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: The material absorbed hydrazine, but remained strong and pliable.

Material tested: Natural rubber
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 22 hr
Results: In 22 hr, the specimen swelled, and the solution became discolored.

Material tested: Natural rubber
Source of data: Ref. 9

Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: A few minutes
Results: The sample swelled immediately on contact with the solution.

Material tested: Natural rubber (U. S. Rubber)
Source of data: Ref. 18
Test Conditions: None given
Results: The material is considered by North American Aviation, Inc., to be satisfactory for extended usage at ambient temperature, or at temperatures up to 200°F for intermittent use.

Material tested: Pure gum rubber
Source of data: Ref. 6
Number of samples tested: 1 or 2
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 1.5% hydrazine decomposition was observed (about the same percentage as that attained with the blank run in glass).

Material tested: Pure gum rubber
Source of data: Ref. 6
Number of samples tested: 1 or 2
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 30 days
Results: Approximately 1% hydrazi[illegible]ition was noted (the blank run in [illegible] indicated 4% decomposition).

19. Rubber (synthetic). Among the synthetic rubbers, compatibility data were found and evaluated for Neoprene, buna N, and four samples of synthetic rubber especially prepared by Picatinny Arsenal.

Neoprene rubber appears to absorb hydrazine rather quickly and, for that reason, should probably be avoided. If required for a specific application, it should be used under static conditions and checked often.

Experimental Data

Material tested: Neoprene
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Sheet
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: The specimen absorbed hydrazine, but still appeared strong and pliable.

Although no blanket recommendation can be made for buna N base rubbers, the two samples tested appeared unaffected over a span of 23 days and would probably be satisfactory for at least a few months. Frequent checks of the material should be made if it is used. This is particularly true for dynamic applications.

Experimental Data

Material tested: Buna N compound 27-351 (Parker Rubber)
Source of data: Unpublished data from JPL test starting July 5, 1956
Number of samples tested: 1
Shape of sample: O-ring
Propellant: 66% N_2H_4–24% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: Ambient
Time: 23 days
Results: No physical change occurred in the O-ring submerged in the test solution. At the end of the test, the diameter was the same as when the sample was placed in the solution. No analysis was made of the solution.

Material tested: Buna N compound SR-349-70 (Stillman Rubber)
Source of data: Unpublished data from JPL test starting July 5, 1956
Number of samples tested: 1
Shape of sample: O-ring
Propellant: 66% N_2H_4–24% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: Ambient
Time: 23 days

Results: No physical change occurred in the submerged specimen. The diameter of the O-ring did not change. No analysis was made of the solution.

Four samples of synthetic rubber were especially prepared by Picatinny Arsenal to resist the action of hydrazine. They were compounded as follows:

Component	Composition in Parts			
	Sample A	Sample B	Sample C	Sample D
Natural rubber	100.0	0.0	0.0	0.0
Butadienstyrene copolymer	0.0	100.0	0.0	0.0
Neoprene	0.0	0.0	100.0	0.0
Butadieneacrylonitrile	0.0	0.0	0.0	100.0
Stearic acid	1.0	1.0	1.0	0.5
Zinc oxide	5.0	5.0	5.0	5.0
Sulphur	1.5	1.5	1.0	1.0
Circo-oil	15.0	15.0	15.0	15.0
Thermatomic carbon black	[illegible]	50.0	50.0	50.0
Pheyl-6-napthylamine	0.0	0.0	2.0	0.0
Benzathiazyldisulphide	1.0	1.0	0.0	1.0

All the compounded synthetic rubbers listed above were found to be completely unsatisfactory with anhydrous hydrazine, as indicated below.

Experimental Data

Materials tested: Synthetic rubbers A, B, C, and D
Source of data: Ref. 9
Number of samples: 1 each
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.4%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 22 hr
Results: All the compounds reacted in 22 hr, swelled, and discolored the solution. The tests were discontinued.

Materials tested: Synthetic rubbers A, B, C, and D
Source of data: Ref. 9
Number of samples tested: 1 each
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.4%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: Up to 4½ hr
Results: Compounds A and B started to swell in 2 hr. Compound C swelled in 4½ hr. Compound D started to swell and disintegrate immediately.

20. Saran. Saran is considered unsatisfactory for use with anhydrous hydrazine or hydrazine nitrate mixtures. Deterioration of the Saran is apparent in a matter of hours.

Experimental Data

Material tested: Saran
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: The sample showed a definite gain in weight (8.7%) and physical-property changes.

Material tested: Saran (B11-K-1791, color S-192B)
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: At the end of the test, the specimen was dark and brittle.

Material tested: Saran
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 3 hr
Results: The material darkened and became brittle in 3 hr.

Material tested: Saran
Source of data: Ref. 9
Number of samples tested: 1

Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.1%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: 2 hr
Results: The material became brittle in 2 hr.

Material tested: Saran
Source of data: Ref. 6
Number of samples tested: 1 or 2
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 2.5% hydrazine decomposition was noted (about 1% more than that for the blank run in glass).

21. Silastic. Silastic appears to be adequate, at least for moderate contact times with anhydrous hydrazine. Additional tests should be run before silastic is used for periods of more than a few weeks with hydrazine nitrate mixtures.

Experimental Data

Material tested: Silastic 167 (Dow-Corning)
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: O-ring from linear mold 3248C
Propellant: Anhydrous hydrazine (94.48%)
Pressure: Atmospheric
Temperature: 15 to 23.9°C (59 to 74°F)
Time: 48 hr
Results: No change occurred in the appearance or flexibility of the sample. The material is considered satisfactory by M. W. Kellogg Company.

Material tested: Silastic
Source of data: Ref. 18
Test conditions: None given
Results: Silastic-type elastomers are considered satisfactory at temperatures up to 300°F for extended usage.

22. Teflon. Teflon is considered to be completely compatible with anhydrous hydrazine, hydrazine hydrate, and hydrazine–hydrazine nitrate–water mixtures. All the organizations that have tested Teflon report no change in its physical properties and no significant decomposition of the hydrazine.

Experimental Data

Material tested: Teflon
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Sheet
Propellant: Anhydrous hydrazine (94.48%)
Pressure: Atmospheric
Temperature: 16 to 25°C (61 to 77°F)
Time: 48 hr
Results: No change in the appearance or properties of the sample was observed.

Material tested: Teflon
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Sheet
Propellant: Hydrazine hydrate
Pressure: Atmospheric
Temperature: 14 to [illegible]°C (57 to 75°F)
Time: 67.5 hr
Results: No attack or change in weight of the sample was observed. The material is considered satisfactory for this service.

Material tested: Teflon
Source of data: Ref. 16
Number of samples tested: 6
Shape of samples: Extruded ⅛-in. sheet
Propellant: Anhydrous hydrazine (96%)
Pressure: Atmospheric
Temperature: Ambient
Time: 119 to 382 days
Results: A very slight gain in weight occurred in all samples. The material is considered satisfactory by M. W. Kellogg Company.

Material tested: Teflon
Source of data: Ref. 8
Number of samples tested: 1
Shape of sample: Sheet
Propellant: $70\%\ N_2H_4$–$25\%\ N_2H_5NO_3$–$5\%\ H_2O$
Pressure: Atmospheric

Temperature: 71°C (160°F)
Time: 9 wk
Results: The sample appeared to have suffered no changes in physical condition. The composition of the solution did not change to any significant degree.

Material tested: Teflon
Source of data: Ref. 5
Number of samples tested: 4
Shape of samples: Sheet
Propellants: 97.5% N_2H_4–1.9% H_2O–0.6% NH_3
78.4% N_2H_4–18.1% $N_2H_5NO_3$–3% H_2O–0.5% NH_3
44.6% N_2H_4–45.3% $N_2H_5NO_3$–9.4% H_2O–0.4% NH_3
19.6% N_2H_4–78.4% $N_2H_5NO_3$–1.8% H_2O–0.2% NH_3
Pressure: Atmospheric
Temperature: Ambient
Time: 370 to 385 days
Results: All the samples were apparently unaffected. The compositions of the solutions did not change appreciably.

Material tested: Teflon
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: No change was observed. The material was strong and pliable and had absorbed no hydrazine.

Material tested: Teflon
Source of data: Ref. 18
Test conditions: None given
Results: The material is considered by North American Aviation, Inc., to be suitable in contact with hydrazine for long-time usage at temperatures up to 500°F.

Material tested: Teflon
Source of data: Ref. 6
Number of samples tested: 1 or 2
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 2% hydrazine decomposition was observed (about ½% more than that noted in the blank run in glass).

Material tested: Teflon
Source of data: Ref. 6
Number of samples tested: 1 or 2
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 30 days
Results: Approximately 2% hydrazine decomposition was observed (about one-half as much decomposition as that noted in the blank run in glass).

Material tested: Teflon
Source of data: Ref. 6
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 4 mo
Results: The sample was unaffected and did not decompose the hydrazine to any extent

23. *Tygon.* Tygon possesses limited suitability for use with anhydrous hydrazine. Contact times should be limited to short periods. The material should not be used with hydrazine nitrate mixtures without further testing.

Experimental Data

Material tested: Tygon
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: The material absorbed hydrazine, but remained

strong and pliable. After drying, the material shrank to its original dimensions.

24. U. S. Rubber Plastic L7825. This material, which is a polymer of butadiene, styrene, and acrylic, appears to be adequate for use with anhydrous hydrazine and hydrazine hydrate for periods of a few weeks. Additional tests should be made if this material is to be used with hydrazine nitrate mixtures or for extended time periods.

Experimental Data

Material tested: U. S. Rubber Plastic L7825
Source of data: Ref. 3
Number of samples tested: 2
Shape of samples: Sheet
Propellant: Anhydrous hydrazine
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 77°F)
Time: 140 hr
Results: The hydrazine turned pink, in each case. A slight loss in the weight of the sample was noted. No change occurred in the appearance of the sample.

Material tested: U. S. Rubber Plastic L7825
Source of data: Ref. 3
Number of samples tested: 2
Shape of samples: Sheet
Propellant: Hydrazine hydrate
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 77°F)
Time: 168 hr
Results: No change in the appearance or weight of the samples was observed.

Material tested: U. S. Rubber Plastic L7825
Source of data: Ref. 18
Test condition: None given
Results: The material is considered by North American Aviation, Inc., to be suitable for long-time ambient-temperature usage with hydrazine.

25. U. S. Rubber Plastic M20995. This material, which is a polyethylene–polyisobutylene polymer, appears to be adequate for use with anhydrous hydrazine and hydrazine hydrate for periods of a few weeks. Additional tests should be made if this material is to be used with hydrazine nitrate mixtures.

Experimental Data

Material tested: U. S. Rubber Plastic M20995
Source of data: Ref. 3
Number of samples tested: 2
Shape of samples: Sheet
Propellant: Hydrazine hydrate
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 77°F)
Time: 188 hr
Results: No change in the appearance of either sample was noted. A slight gain in weight occurred in each sample.

Material tested: U. S. Rubber Plastic M20995
Source of data: Ref. 18
Test conditions: None given
Results: The material is considered by North American Aviation, Inc., to be suitable in contact with hydrazine for long-time ambient-temperature uses.

26. Veloform. Veloform is considered to be unsatisfactory for use with hydrazine–hydrazine nitrate–water mixtures and, in all likelihood, would be unsatisfactory with anhydrous hydrazine.

Experimental Data

Material tested: Veloform (F-10CPP284)
Source of data: Ref. 10
Number of samples tested: 2
Shape of samples: Sheet
Propellant: 45% N_2H_4–45% $N_2H_5NO_3$–10% H_2O
Pressure: Atmospheric
Temperature: 72 to 74°C (161 to 165°F)
Time: 7 days
Results: The samples showed a definite gain in weight; the material decomposed and swelled, and the color changed from white to black.

C. Miscellaneous Materials

1. Asbestos. Asbestos apparently is not physically attacked to any degree by anhydrous hydrazine. Its form of manufacture, however, appears to be the principal factor in determining its acceptability. In an oral communication from the Fairmount Chemical Company to the Battelle Memorial Institute, it was pointed out that hard asbestos was found satisfactory for gasketing and valve packing, but that soft asbestos, because of its porous nature and, hence, its large surface area, burst into flame when soaked with hydrazine and exposed to air; even hard asbestos must be watched carefully for frayed edges, which may become soaked with hydrazine (Ref. 6). Battelle also reports, on the basis of communication with Western Cartridge Company (Ref. 6), that an accident at the Western Cartridge plant was traced to asbestos soaked with hydrazine. Mathieson Chemical Corporation has stated that asbestos acts to catalyze the decomposition of hydrazine (Ref. 2).

It is recommended, therefore, that asbestos be avoided if possible. If it is necessary to use asbestos, only hard asbestos should be used, and frequent inspection should be undertaken.

Experimental Data

Material tested: Asbestos
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: No change in the specimen was noted.

Material tested: Asbestos
Source of data: Ref. 18
Test conditions: None given
Results: This material is considered by North American Aviation, Inc., to be suitable.

Material tested: Asbestos (Pyroid)
Source of data: Ref. 6
Number of samples tested: 1 or 2
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 2.0% hydrazine decomposition was observed (a blank run in glass showed 1.5% decomposition).

Material tested: Asbestos (Vellumoid)
Source of data: Ref. 6
Number of samples tested: 1 or 2
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 2.0% hydrazine decomposition was observed (about ½% higher than that for a blank run in glass).

2. Glass. Glass, both soft and hard (Pyrex), is considered to be completely satisfactory for contact with anhydrous hydrazine and hydrazine nitrate mixtures. Picatinny Arsenal reports that anhydrous hydrazine stored in both hard- and soft-glass bottles at room temperature caused solution of the glass after 12-mo storage. The nonvolatile content was 0.02% at 65°C (149°F), indicating only a very slight amount of solution. The hydrazine stored in both hard and soft glass at room temperature underwent practically no decomposition after 1 year. At 65°C (149°F), some hydrazine decomposition occurred; however, since the bottles were opened frequently to extract samples, it is believed that the decomposition was not causd by the glass.

Experimental Data

Material tested: Soft glass
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Rod
Propellant: Anhydrous hydrazine (95.4%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 12 mo
Results: No change in the weight or appearance of the sample was noted.

Material tested: Hard glass (Pyrex)
Source of data: Ref. 9

Number of samples tested: 1
Shape of sample: Rod
Propellant: Anhydrous hydrazine (95.4%)
Pressure: Atmospheric
Temperature: 21 to 23°C (70 to 73°F)
Time: 12 mo
Results: No change in the weight or appearance of the sample was observed. In a separate test, a hard-glass bottle containing hydrazine of 95.4% composition before storage showed a composition of 93.1% after 12 mo. The bottle had been opened and closed many times and had air above the liquid.

Material tested: Soft glass
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Rod
Propellant: Anhydrous hydrazine (95.4%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: 12 mo
Results: No change in the weight or appearance of the sample was noted at the end of the test.

Material tested: Hard glass (Pyrex)
Source of data: Ref. 9
Number of samples tested: 1
Shape of sample: Rod
Propellant: Anhydrous hydrazine (95.4%)
Pressure: Atmospheric
Temperature: 65°C (149°F)
Time: 12 mo
Results: No change in the weight or appearance of the sample had appeared at the end of the test. In a separate test, a hard-glass bottle containing hydrazine of 95.4% composition at the start of the test showed a concentration of 9[illegible].9% after 12 mo. The container had been opened several times and air had been admitted above the liquid.

Material tested: Glass
Source of data: Ref. 6
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 4 mo
Results: The sample was unaffected and did not decompose the hydrazine to any extent.

3. ***Graphite.*** It is believed that graphite presents much the same type of compatibility problem as does asbestos. That is, the form in which the graphite is processed is the controlling factor in its compatibility. It appears that physically, graphite is relatively unaffected by hydrazine.

The use of graphite should probably be avoided, if possible. If it is required for a specific application, care should be taken to utilize graphite of low porosity, and frequent inspections should be made.

Experimental Data

Material tested: Natural carbon porous graphite, grade 60
Source of data: Ref. 3
Number of samples tested: 1
Propellant: Anhydrous hydrazine
Pressure: Atmospheric
Temperature: 15 to 24°C (59 to 75°F)
Time: 48 hr
Results: The material itself was apparently unaffected; however, there was a greater-than-normal decomposition of the hydrazine. The material is not recommended by M. W. Kellogg Company.

Material tested: Graphite valve packing
Source of data: Ref. 4
Number of samples tested: 1
Shape of sample: Strip
Propellant: Anhydrous hydrazine (95.6%)
Pressure: Atmospheric
Temperature: 20°C (68°F)
Time: 24 days
Results: No change in the specimen was noted.

4. ***Graphitar.*** Because of the close similarity of graphitar to graphite, it is believed that the evaluation given for graphite adequately describes the compatibility of graphitar.

Experimental Data

Material tested: Graphitar 2 (U. S. Graphite)
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Cut from foil
Propellant: Anhydrous hydrazine (94.48%)
Pressure: Atmospheric
Temperature: 15 to 23.2°C (59 to 74°F)
Time: 48 hr
Results: The material itself was apparently unaffected; however, there was a greater-than-normal decomposition of the hydrazine. The material is not recommended by M. W. Kellogg Company.

Material tested: Graphitar 50 (U. S. Graphite)
Source of data: Ref. 3
Number of samples tested: 1
Shape of sample: Cut from foil
Propellant: Anhydrous hydrazine (94.48%)
Pressure: Atmospheric
Temperature: 15.3 to 22°C (59 to 72°F)
Time: 48 hr
Results: The material itself was unaffected; however, there was a greater-than-normal decomposition of the hydrazine. The material is not recommended by M. W. Kellogg Company.

Material tested: Graphitar 2
Source of data: Ref. 18
Test conditions: None given
Results: The material is considered suitable in contact with hydrazine by North American Aviation, Inc.

Material tested: Graphitar 50
Source of data: Ref. 18
Test conditions: None given
Results: The material is considered suitable in contact with hydrazine by North American Aviation, Inc.

5. Pipe-joint compounds. North American Aviation, Inc., rates all three of the compounds listed below as being acceptable for hydrazine service. However, no detailed experimental data are given regarding test conditions, etc.

Experimental Data

Material tested: AN-C-53 thread compound (Socony-Vacuum and others)
Source of data: Ref. 18
Test conditions: None given
Results: The material is considered suitable for hydrazine service.

Material tested: Oxyseal (Parker Appliance)
Source of data: Ref. 18
Test conditions: None given
Results: The material is considered suitable for hydrazine service.

Material tested: Thread-Tite (Armite Laboratories)
Source of data: Ref. 18
Test conditions: None given
Results: The material is considered suitable for hydrazine service.

6. Rags. Liquid hydrazine, when in contact with an organic material such as wiping rags, may smoulder and burst into flame. Rags should not be used to pick up spillage (Ref. 2).

7. Silicone lubricants. The silicone lubricants listed below are apparently suitable for moderate contact with hydrazine. Additional data should be obtained before any long-term applications are considered.

Experimental Data

Material tested: Silicone lubricant DC-710
Source of data: Ref. 3
Number of samples tested: 1
Propellant: Hydrazine hydrate
Pressure: Atmospheric
Temperature: 19 to 25°C (66 to 77°F)
Time: 67.5 hr
Results: A slight scum had appeared on the surface of the hydrazine at the end of the test. The silicone was slightly decomposed.

Material tested: Silicone lubricant DC-710
Source of data: Ref. 18
Test conditions: None given
Results: The material is considered by North American Aviation, Inc., to be suitable in contact with hydrazine. It will be thermally stable at temperatures up to 500°F.

Materials tested: Silicone lubricants, DC-200 series
Source of data: Ref. 18
Test conditions: None given
Results: The lubricants are considered by North American Aviation, Inc., to be suitable in contact with hydrazine.

Material tested: Silicone lubricant DC-550
Source of data: Ref. 18
Test conditions: None given
Results: The material is considered by North American Aviation, Inc., to be suitable in contact with hydrazine.

Material tested: Silicone plug-cock grease (Dow-Corning)
Source of data: Ref. 18
Test conditions: None given
Results: The material is considered by North American Aviation, Inc., to be suitable in contact with hydrazine.

8. Solder (lead-tin). The experimental data available indicate that, from a corrosion standpoint, lead-tin solder would be acceptable in contact with hydrazine at ambient conditions for at least a week. However, in view of the poor behavior exhibited by metallic lead, as well as the fact that oxides of tin reduce the ignition temperature of hydrazine, it is believed that the material should be avoided. Silver solder would appear to be a better choice where soldering is required.

Experimental Data

Material tested: Solder (90% Pb, 10% Sn)
Source of data: Ref. 3
Number of samples tested: 2
Shape of samples: Rolled sheet
Propellant: Anhydrous hydrazine (93.23%)
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 77°F)
Time: 211 and 211.5 hr
Results: The penetration/year is negligible.

Material tested: Solder (90% Pb, 10% Sn)
Source of data: Ref. 3
Number of samples tested: 2
Shape of samples: Rolled sheet
Propellant: Vapor over anhydrous hydrazine (93.23%)
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 77°F)
Time: 211 and 211.5 hr
Results: The penetration/year is negligible.

Material tested: Solder (90% Pb, 10% Sn)
Source of data: Ref. 3
Number of samples tested: 2
Shape of samples: Rolled sheet
Propellant: Hydrazine hydrate (66.56%)
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 77°F)
Time: 143 and 210 hr
Results: No corrosion or change in the weight of the samples was observed.

Material tested: Lead-tin solder
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 3.75% hydrazine decomposition was noted (the blank run in glass showed 1.5% decomposition).

Material tested: Lead-tin solder
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 30 days
Results: Approximately 3% hydrazine decomposition was

observed (about 1% less than the decomposition appearing in the blank run in glass).

9. Solder (silver). Silver solder appears to be acceptable, at least for short-term or intermittent contact with anhydrous hydrazine and hydrazine hydrate. Experience at this Laboratory indicates equal acceptability with hydrazine nitrate mixtures.

For longer-term applications, additional tests, as well as periodic inspections, should be made because of the possibility of leaching-out the zinc.

Experimental Data

Material tested: Easy Flo silver solder (50% Ag, 15.5% Cu, 16.5% Zn, 18% Cd)
Source of data: Ref. 3
Number of samples tested: 2
Shape of samples: ⅛-in. rod
Propellant: Anhydrous hydrazine (93.23%)
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 77°F)
Time: 165 to 190 hr
Results: No corrosion was evident, and the penetration/year was negligible.

Material tested: Easy Flo silver solder
Source of data: Ref. 3
Number of samples tested: 2
Shape of samples: ⅛-in. rod
Propellant: Vapor over anhydrous hydrazine (93.23%)
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 77°F)
Time: 211 and 211.5 hr
Results: No corrosion and no penetration/year were observed.

Material tested: Easy Flo silver solder
Source of data: Ref. 3
Number of samples tested: 2
Shape of samples: ⅛-in. rod
Propellant: Hydrazine hydrate (66.56%)
Pressure: Atmospheric
Temperature: 20 to 25°C (68 to 77°F)
Time: 141.5 and 142 hr
Results: No corrosion, penetration/year, or change in the weight of the samples was noted.

Material tested: Easy Flo silver solder
Source of data: Ref. 3
Number of samples tested: 2
Shape of samples: ⅛-in. rod
Propellant: Anhydrous hydrazine (96.06%)
Pressure: Atmospheric
Temperature: 110 to 125°C (230 to 257°F)
Time: 50 hr
Results: No corrosion or change in weight was noted for either sample.

Material tested: Silver solder
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 26°C (80°F)
Time: 30 days
Results: Approximately 3% hydrazine decomposition was observed (about twice that noted with the blank run in glass).

Material tested: Silver solder
Source of data: Ref. 6
Number of samples tested: 1 or 2
Shape of samples: Strip
Propellant: Anhydrous hydrazine (95.5%)
Pressure: Closed system, initially atmospheric
Temperature: 60°C (140°F)
Time: 30 days
Results: Approximately 9% hydrazine decomposition was observed (about twice as much as that for the blank run in glass).

10. Varnish. North American Aviation, Inc., indicates at least short-term protection with varnishes utilizing silicone resins of the DC-800 series.

Material tested: Varnish (formulated with DC-800-series silicone resins)
Source of data: Ref. 18
Test conditions: None given

Results: This material will provide adequate splash protection and will withstand immersion for short periods.

11. Wool. Liquid hydrazine in contact with an organic material such as wool may start to burn spontaneously. Wool should never be used near hydrazine (Ref. 2).

REFERENCES

1. Troyan, J. E., "Safety in the Handling of Hydrazine," *Symposium on Hydrazine and Its Applications,* Olin Mathieson Chemical Corporation, Baltimore, Maryland, February 2 to 3, 1953 (Report FRO 20[illegible], Vol. I, Department of Defense, Research and Development Board, Washington, D. C.) (Confidential).

2. Clark, C. C., *Hydrazine,* Olin Mathieson Chemical Corporation, Baltimore, Maryland, 1953.

3. *6000-Pound-Thrust Jet Propulsion Unit, Part II. Materials Corrosion Data, Final Report, Vol. VII,* Report No. SPD 121. M. W. Kellogg Company, Jersey City, New Jersey, March 19, 1948.

4. Ordin, P. M., *Preliminary Investigation of Hydrazine as a Rocket Fuel,* Research Memorandum No. E7H21. National Advisory Committee for Aeronautics, Washington, D. C., May 24, 1948.

5. Dwiggins, R. D., et al, *Investigation of Mixtures of Hydrazine, Hydrazine Nitrate, Water,* NAVORD Report No. 2787. U. S. Naval Ordnance Laboratory, White Oak, Maryland, June 18, 1953 (Confidential).

6. Peterson, F. D., and Clegg, J. W., *Behavior of Commercial Hydrazine in Contact with Various Materials,* Report to Project RAND, Rand designation RM-504. Batelle Memorial Institute, Columbus, Ohio, August 1, 1950.

7. *Development of Monopropellant Hydrazine as a Liquid Propellant for Guns,* Bimonthly Progress Reports, Contract NOrd 12649. Olin Mathieson Chemical Corporation, Baltimore, Maryland, 1952 (Confidential).

8. Dwiggins, R. D., et al, *Investigation of Mixtures of Hydrazine, Hydrazine Nitrate, Water,* NAVORD Report No. 2964. U. S. Naval Ordnance Laboratory, White Oak, Maryland, September 23, 1953 (Confidential).

9. Livingston, S., *Determination of the Characteristics of Liquid Propellants: Explosive, Handling, and Storage Characteristics of Hydrazine,* Technical Report No. 1732. Picatinny Arsenal, Dover, New Jersey, May 16, 1949 (Confidential).

10. Dwiggins, R. D., et al, *Investigation of Mixtures of Hydrazine, Hydrazine Nitrate, Water,* NAVORD Report No. 2255. U. S. Naval Ordnance Laboratory, White Oak, Maryland, February 1, 1952 (Confidential).

11. *Development of Monopropellant Hydrazine as a Liquid Propellant for Guns,* Bimonthly Progress Report, Contract NOrd 12649, Task I. Olin Mathieson Chemical Corporation, Baltimore, Maryland, February 19, 1953 (Confidential).

12. *MX-776 Rocket Power Plant,* Quarterly Progress Report No. 56-981-015. Bell Aircraft Corporation, Niagara Falls, New York, December 31, 1953 (Confidential).

13. *Development of Monopropellant Hydrazine as a Liquid Propellant for Guns,* Final Summary Report, Contract NOrd-12649. Olin Mathieson Chemical Corporation, Baltimore, Maryland, May 31, 1953 (Confidential).

14. Audrieth, L. F., and Ogg, B. A., *The Chemistry of Hydrazine,* John Wiley & Sons, Inc., New York, 1951.

15. Dwiggins, R. D., et al, *Investigation of Mixtures of Hydrazine, Hydrazine Nitrate, Water,* NAVORD Report No. 2715. U. S. Naval Ordnance Laboratory, White Oak, Maryland, January 9, 1953 (Confidential).

REFERENCES (Cont'd)

16. Freeman, A., et al, *Preliminary Experimental Studies of Liquid Fuel Systems*, Final Report No. SPD 236. M. W. Kellogg Company, Jersey City, New Jersey, ... 20, 1949.

17. *Theoretical, Laboratory, and Experimental Investigations of High Energy Propellants: Hydrazine, Vol. II*, Report No. RMI-293-S11. Reaction Motors, Inc., Rockaway, New Jersey, November 20, 1950.

18. De Dapper, J. W., and Nadler, M., *Nonmetallic Materials for Use with Liquid Rocket Propellants*, Report No. AL-692. North American Aviation Inc., Los Angeles, California, May 1, 1951.

UNCLASSIFIED

UNCLASSIFIED