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ENGINEERING REPORT

Wyle Report No. 57694
Wyle Job No. NES 57694
Customer P.O. No. 14926-EQ01EQ Task 12
Total Pages this Report 12
Date: February 25, 1985

Revision A - June 12, 1985

AGING ANALYSIS
OF
NON-METALLIC MATERIAL
OF
PACKLESS METAL DIAPHRAGM VALVES

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REVISIONS

Rev.No.	Date	Pages Affected	Preparer	Reviewer	QA	PE	Description of Changes
A	6/12/85	2, 11	S.P.	PD	6-13-85		Incorporated Customer Comments

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1.0 SCOPE

This document was prepared by Wyle Laboratories for Bechtel Energy Corporation (BEC) for equipment to be used in the South Texas Project Electric Generating Station.

1.1 Objectives

The purpose of this report is to perform an aging analysis of non-metallic materials used in the packing rings of the Kerotest Packless Metal Diaphragm valves listed in Section 1.3.

The aging analysis of non-metallic materials was based on the criteria of susceptibility to time/temperature and radiation mechanisms.

1.2 Applicable Qualification Standards and Documents

- IEEE 323-1974 "Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Station".
- IEEE 627-1980 "Standard for Design Qualification of Safety Systems Equipment Used in Nuclear Power Generating Stations".
- Bechtel Specification 4A479ES1018, Rev. 2, "Specification for the Environmental Qualification of Safety-Related Electrical and Mechanical Equipment for the Houston Lighting and Power Company South Texas Project Electric Generating Station".
- Bechtel Specification 1L529TS0104, Rev. 0, "Specification for ASME Section III Bellow Seal or Packless Metal Diaphragm Valves 2 inches and smaller for the Houston Lighting and Power Company, South Texas Project Electric Generating Station," with Addendum 1, January 17, 1983.
- Wyle Laboratories Western Test and Engineering, Quality Assurance Manual, 380 Rev. D dated 15 April 1984.

1.3 Non-Metallic Materials

The subject of this analysis is non-metallic materials used in the Kerotest Packless Metal Diaphragm Valves listed in Table 1.

TABLE 1

LIST OF NON-METALLIC MATERIALS

IDENTIFICATION NUMBER	PACKING MATERIAL	VSS NO.	LOCATION
1/2DH 26SS 3A-C	2CRJ	48	Outside RCB
1/2DH 26SS 3B-C	2CRJ	49	Inside RCB
1/2DH 46SS 3A-C	2CRJ	50	Outside RCB
1/2DH 46SS 2A-J	2CRJ	1	Outside RCB
1/2DH 46SS 2B-J	1871	2	Inside RCB
1/2DH 46SS 2C-J	1871	3	Outside RCB
1/2DH 46SS 3A-J	1871	4	Outside RCB
1/2DH 46SS 3C-J	1871	5	Inside RCB
1/2DH 46TJ 2B-C	Grafoil	89	Inside RCB
1/2DH 46SS 2B-J	2CRJ	73	Outside RCB
1/2DH 26SS 2A-C	1871	51	Inside RCB
1/2DH 26SS 2B-C	1871	52	Outside RCB
1/2DH 26SS 3A-C	2CRJ	83	Inside RCB
3/4DH 26SS 3B-C	1871	6	Inside RCB
3/4DH 46SS 1B-J	1871	7	Inside RCB
3/4DH 46SS 1BBJ	1871	53	Outside RCB
3/4DH 46SS 2A-J	1871	8	Inside RCB
3/4DH 46SS 2B-J	1871	10	Inside RCB
3/4DH 46SS 2BBJ	1871	11	Outside RCB
3/4DH 46SS 2C-E	1871	54	Outside RCB
3/4DH 46SS 2C-J	1871	12	Outside RCB
3/4DH 46SS 3A-J	1871	14	Outside RCB
3/4DH 46SS 3B-J	1871	15	Inside RCB
3/4DH 46SS 3C-J	1871	16	Outside RCB
3/4NH 42SS 3CBJ	1871	74	Outside RCB
1 DH 26SS 1B-C	1871	91	Inside RCB
1 DH 26SS 2A-A	1871	82	Outside RCB
1 DH 26SS 2A-C	1871	55	Outside RCB
1 DH 26SS 2B-C	1871	87	I.V.C.
1 DH 26SS 3A-C	1871	18	Outside RCB
1 DH 26SS 3B-B	1871	86	Inside RCB
1 DH 26SS 3B-C	1871	56	Inside RCB
1 DH 46SS 1B-C	1871	90	Inside RCB

1.3 Non-Metallic Materials, (Continued)

IDENTIFICATION NUMBER	PACKING MATERIAL	VSS NO.	LOCATION
1 DH 46SS 1B-J	1871	19	Inside RCB
1 DH 46SS 2A-C	1871	79	Outside RCB
1 DH 46SS 2A-J	1871	57	Outside RCB
1 DH 46SS 2ABJ	1871	58	Outside RCB
1 DH 46SS 2B-C	1871	88	Inside RCB
1 DH 46SS 2B-J	1871	20	Inside RCB
1 DH 46SS 2BBJ	1871	59	Inside RCB
1 DH 46SS 2C-E	1871	80	Outside RCB
1 DH 46SS 2C-J	1871	60	Inside RCB
1 DH 46SS 3A-C	1871	61	Outside RCB
1 DH 46SS 3A-J	1871	21	Outside RCB
1 DH 46SS 3BBJ	1871	63	Inside RCB
1 DH 46SS 3B-B	1871	84	Inside RCB
1 DH 46SS 3B-J	1871	62	Inside RCB
1 DH 46SS 3C-J	1871	64	Outside RCB
1 NH 46SS 2BBJ	1871	75	Inside RCB
1-1/2DH 26SS 2B-C	1871	81	Inside RCB
1-1/2DH 26SS 3A-C	1871	65	Outside RCB
2 DH 26SS 3A-C	1871	66	Outside RCB
2 DH 26SS 3B-B	1871	85	Inside RCB
2 DH 46BP 1BBJ	1871	78	Inside RCB
2 DH 46SS 1B-J	1871	22	Inside RCB
2 DH 46SS 1BBJ	1871	67	Inside RCB
2 DH 46SS 2A-J	1871	23	Outside RCB
2 DH 46SS 2ABJ	1871	24	Outside RCB
2 DH 46SS 2B-J	1871	25	Outside RCB
2 DH 46SS 2C-J	1871	26	Outside RCB
2 DH 46SS 3A-J	1871	27	Outside RCB
2 DH 46SS 3ABJ	1871	68	Outside RCB
2 DH 46SS 3B-J	1871	69	Inside RCB
2 DH 46SS 3BBJ	1871	70	Inside RCB
2 DH 46SS 3C-J	1871	28	Outside RCB
2 DM 46SS 2B-J SXH	1871	31	Inside RCB
2 KR 46SS 2A-J	1871	38	Outside RCB
2 KR 46SS 2C-J	1871	40	Outside RCB
2 KR 46SS 2CBJ	1871	41	Outside RCB
2 NH 42SS 3CBJ	1871	76	Outside RCB
2 NH 46SS 2BBJ	1871	77	Inside RCB

1.3 Non-Metallic Materials, (Continued)

IDENTIFICATION NUMBER	PACKING MATERIAL	VSS NO.	LOCATION
2ACTDM 46BP 1B-J FXX	1871	92	Inside RCB
2ACTDM 46SS 2A-J FXX	1871	33	Outside RCB (Other than IVC)
2CTRDM 46SS-2B-J FXX	1871	71	Inside RCB
2ACTDM 46SS 2C-J FXX	1871	72	Outside RCB (Other than IVC)
2ACTDM 46SS 3A-J FXX	1871	34	Outside RCB (Other than IVC)

NOTES:
- 2CRJ = John Crane 2CRJ (Braided Asbestos with Resilient Plastic Core)
- 1871 = John Crane 1871 (Braided Asbestos with Inconel Wire)
- Grafoil = Garlock Grafoil (graphite) with zinc spacers

2.0 DEFINITION OF SERVICE CONDITION

BEC has specified the following environmental service conditions (Ref. 1).

2.1 Valves for Inside Containment Service

Valves designed for inside containment service will be subjected to the following harsh environmental conditions:

	Normal Conditions	Accident
Pressure	+0.3 psig (Max) -0.1 psig (Min)	48.4 psig (Max) -3.1 psig (Min)
Temperature	65°F (Min), 120°F (Max)	323°F
Radiation	2.0×10^7 rads (40 years)	1.4×10^8 rads (180 days)
Relative Humidity	0-80 percent	100 percent
Radiation Type	gamma	gamma and beta

2.0 DEFINITION OF SERVICE CONDITION, (Continued)

2.2 Valves for Outside Containment Service (Excluding IVC RMS 054, 244 A Thru T)

Valves designed for outside containment service will be required to operate under the following worst-case harsh environmental conditions:

	Normal Conditions	Accident
Pressure	Atm	2.1 psig
Temperature	135° (Max) 50°F (Min)	240°F
Radiation	10^7 rads (40 years)	8×10^6 rads (180 days)
Relative Humidity	0 to 80 percent	100 percent
Radiation Type	gamma	gamma

2.3 Valves for Isolation Valve Cubicle (IVC) Service

Valves (excluding operators) designed for IVC will be subjected to the following worst-case harsh environmental conditions:

	Normal Conditions	Accident
Pressure	Atm	5.8 psig
Temperature	104°F (max) 29°F (min)	335°F
Radiation	100 rads (40 years)	3.5×10^5 rads (180 days)
Relative Humidity	0 to 80 percent	100 percent
Radiation Type	gamma	gamma

3.0 EVALUATION CRITERIA

3.1 Evaluation of Susceptibility to Radiation Degradation

The approach for evaluating radiation sensitive materials of the valves is a two-step process:

1. Research Wyle Laboratories Aging Library for information on threshold levels, severe damage levels, degradation characteristics, and failure criteria.

2. Provide evaluation based on potential material degradation and ability to perform its design function after exposure to the specified radiation dosage.

3.2 Evaluation of Susceptibility to Time/Temperature Related Mechanisms

For many organic materials, it is known that the degradation process can be defined by a single temperature-dependent reaction that follows the Arrhenius equation (Ref. 1 and 3):

$k = A \exp(-(Ea/k_B T))$

where,

k = reaction rate

A = frequency factor

exp = exponent to base e

Ea = activation energy

k_B = Boltzmann's Constant (8.617×10^{-5} eV/K)

T = absolute temperature

3.2 Evaluation of Susceptibility to Time/Temperature Related Mechanisms (Con't.)

It is further noted that, for many reactions, the activation energy can be considered to be constant over the applicable temperature range. Life is assumed to be inversely proportional to the chemical reaction rate (Ref. 2 and 4). In terms of life, and after converting to Napierian base logarithms, equation (1) becomes:

$$\ln(\text{life}) = (Ea/k_B)(1/T) + \text{Constant} \qquad (2)$$

Equation (2) has the algebraic form:

$$y = mx + b,$$

where

$y = \ln(\text{life})$

$x = 1/T$

$m = Ea/k_B$, constant for single dominant reactions

b = constant

The constants, m and b, can be estimated by fitting the experimental data in the form of ln(life) versus 1/T to the above simple linear relationship.

For example, Dow Corning #732 RTV Silicone Rubber with a failure criterion of 50% elongation:

$$\ln(\text{life}) = 8956.8356(1/T) - 11.4998$$

for a baseline temperature of 313K (104°F)

$\text{life} = 3.09 \times 10^3$ years

4.0 EVALUATION

Three types of packing rings are used in the Kerotest Packless Metal Diaphragm Valves. These three types of rings are: John Crane type 1871, John Crane type 2CRJ and Garlock Grafoil.

1871 packing rings are made of braided pure asbestos yarn with an Inconel wire inserted around a resilient asbestos core and impregnated with Graphite. The 2CRJ type packing ring is made of asbestos with a Neoprene binder and graphite lubricant.

Grafoil packing rings are an all graphite packing containing no resin binders or inorganic fillers.

Asbestos and graphite are high temperature and radiation resistant materials. The following paragraphs discuss the effect of radiation and temperature on the packing rings made of these materials.

4.1 Radiation

The radiation damage threshold for packing ring type 1871 is 10^7 rads gamma (Ref. 5, 6).

The radiation damage threshold level for type 2CRJ packing is 8.0E5 (Ref. 7). This radiation damage threshold is based on the damage threshold of the binder material (Neoprene).

The radiation damage threshold level for the Grafoil packing ring is 1.5×10^9 rads (Ref. 6).

Grafoil packing is insensitive to the radiation levels specified in Paragraph 2.0. John Crane packing ring types 1871 and 2CRJ are insensitive to the radiation level of the IVC area. These two types of packing rings are sensitive to the total integrated radiation dose of areas other than the IVC.

4.2 Time/Temperature Aging

The packing rings are made of non-organic materials, except for the Neoprene used as a binder in the 2CRJ type. Types 1871, 2CRJ and Grafoil have temperature ratings of 1200°F, 700°F and 1000°F respectively (Ref. 6).

The non-organic materials, asbestos, graphite and metal, are not sensitive to the effects of the time/temperature aging. Neoprene is the weak link material of the 2CRJ type ring. The Arrhenius parameters for Neoprene when used as a gasket are:

Slope	=	12190.06379 (Ref. 8)
Intercept	=	-24.09326 (Ref. 8)

4.2 Time/Temperature Aging, (Continued)

The worst case normal service temperature specified in paragraph 2.0 is 135°F. The expected life of the Neoprene material when used as a gasket, in the worst case service temperature, is greater than 40 years. The effects of time/temperature aging on the 2CRJ ring is judged insignificant in 40 years, because the Neoprene expected life exceeds 40 years and its application is as a binder.

Since time/temperature effects are insignificant for these packing rings in 40 years, shelf life is not a concern, if the packing rings are stored per Manufacturer recommendation.

4.2.1 Temperature/Pressure Effects

Reference 9 is a report of temperature and pressure testing of the braided asbestos-graphite impregnated and grafoil packing rings in a borated water system . The test objective was to determine the leakage rate when valves containing these types of packing rings were subjected to a number of high temperature, pressure cycles. Tests were conducted at 2000 psi at 130°F, and 2250 psi at 550-650°F.

This test program showed that braided asbestos-graphite impregnated packings are not recommended for critical nuclear services where high pressure borated water is encountered and periodic gland adjustments cannot be performed.

This test program also showed that packing rings made of grafoil are superior to braided asbestos-graphite.

4.3 Humidity

The packing materials in all of the valves are sealed against the outside humidity and therefore the humidity has no significant effect on aging of the non-metallic materials used in the valves.

5.0 CONCLUSION

John Crane 1871 and 2CRJ packing rings are not significantly affected by time/temperature aging and humidity in 40 years of normal service. However, these packing rings have radiation damage thresholds that are lower than the required TID except for the IVC location of the plant. Therefore, this analysis cannot support the qualification of John Crane 1871 and 2CRJ packing rings (see Table 1 for those valves with these types of packing ring materials). Moreover, these packing rings are not recommended for high pressure borated water service and where periodic gland adjustments cannot be performed. Grafoil packing rings, however, are not affected by the required radiation and time/temperature and humidity effects in 40 years and are therefore qualified for this period of time.

6.0 REFERENCES

1. Bechtel Task Description, Task No. EQ0qEQ-4032EQ1, Rev. 0

2. "IEEE Guide for the Statistical Analysis of Thermal Life Test Data, "IEEE 101-1972, Library Code 265-80

3. "A Review of Equipment Aging Theory and Technology," S.P. Carfagno and R.J. Gibson, Franklin Research Center, Electric Power Research Report No. EPRI-NP-1558, Library Code 600-82

4. Handbook of Engineering Fundamentals, 3rd Edition, O.W. Eshback and M. Sanders, pp. 1284, John Wiley & Sons, 1975, Library Code 247-80

5. Severe Service Graphite Filament Yarn Packing, John Crane Bulletin No. P-3006-2

6. Wyle Contact Report with Kerotest, dated January 23, 1985, Report by Shayan Pazargadi

7. "The Use of Plastics and Elastomers in Nuclear Radiation," W.W. Parkinson and O. Sisman, Library Code 438-81

8. "Wires and Cords for Original Equipment Manufacturers," General Electric Company, No. WCC-2, Library Code 185-79A

9. Rockwell-Edward Univalve Borated Water Stem Packing Tests, by Roger D. Norden, Supervisor Product Engineering Valve Engineering and Research, Rockwell Manufacturing Company

WESTINGHOUSE LETTER ST-WN-YB-2875

ST-WN-YB-2875

FILE NO E242

Westinghouse Electric Corporation Power Systems

	ATTACH	WILL ATT		ATTACH	WILL ATT
PROJ. MGR.		X	PEM-SITE		
PEM			EGS-ARCH		
PROC Coord Mgr			EGS-CIVIL		
PE-CONFIG MGT			EGS-CONTROLS		
PE-SYSTEMS			EGS-ELEC		
PE-PHYSICAL			EGS-EQ		X
PE-NUC/LIC		X	EGS-MECH		
APE-QE/CONT			EGS-NUCLEAR		
COMPLET MGR			EGS-PLNT DES		
NSSS COORD		X	EGS-PSSG		
RMS (2)		X	EGS-QE		
					X

Nuclear Technology Systems Division

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September 16, 1986

S.O. No: TGX 219

Ref.: ST-YB-WN-1599

Action Item No.: 1058

Mr. A. Matiuk
Project Engineering Manager
Bechtel Energy Corporation
5400 Westheimer Court
P.O. Box 2166
Houston, Texas 77252-2166

SOUTH TEXAS PROJECT
UNITS NUMBERS 1 & 2
CONTRACT NUMBERS 35-1197-4000 AND 35-1197-8000
JOHN CRANE VALVE PACKING RADIATION RESISTANCE

Dear Mr. Matiuk:

On the reference letter BEC noted that NSSS supplied valves 8901 A/B/C qualified under WCAP 11024 have John Crane 1871 packing rings. BEC also noted per WCAP 11024 packing rings are qualified to 1.0×10^{10} rads gamma and John Crane bulletin shows and John Crane letter attached to the reference confirms a radiation resistance dose of 1.0×10^{7} rads gamma. BEC requested, in the reference, that Westinghouse provide clarification and justification for the 1.0×10^{10} rads gamma radiation resistance for valves with John Crane 1871 packing rings.

The radiation threshold limit of John Crane 187-I Packing is 1×10^{7} rad as reported in the referenced letter. This threshold limit is based on the Buna S binder that makes up at most 10% of the packing material. The other 90% of the packing material is comprised of asbestos and graphite which are very radiation resistant materials and have a minimum radiation threshold of 1×10^{10} rads.

Westinghouse assigned a radiation limit of 1×10^{10} rads in WCAP 11024 based upon the functions of the individual components of John Crane 187-I. The asbestos and graphite fibers are the primary components of the 187-I packing rings. The Buna S binder is used to help keep these fibers in place during handling and installation. Once the packing rings are placed in the stuffing box and compressed, the packing rings assume the shape of the stuffing box. Thus, once installed, the packing rings will maintain their shape and perform their function even if the Buna S binder becomes brittle when subjected to radiation levels greater than 1×10^{7} rads because the asbestos and graphite perform the primary packing function.

Therefore, Westinghouse concludes that John Crane 187-I Packing is acceptable for radiation levels up to 1×10^{10} rads because the asbsestos and graphite fibers perform their primary packing function and maintain their shape even if the Buna S binder becomes brittle due to radiation levels greater than 1×10^{7} rads.

Very truly yours,

WESTINGHOUSE ELECTRIC CORPORATION

F. J. Twogood, Manager
South Texas Project

CVernon/ajs/1748F:1

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ASSEMBLY DRAWING & PARTS LIST

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BEC LOG NO. 14926-0220(1)-00234-BWN
14926-0220(2)-00234-BWN

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MECHANICAL EQUIPMENT QUALIFICATION APPROACH

AND

FLOW DIAGRAM

(Excerpts from MEQ-1 Report, Section 5,pages 5-1 & 5-2)

5.0 MECHANICAL EQUIPMENT QUALIFICATION APPROACH

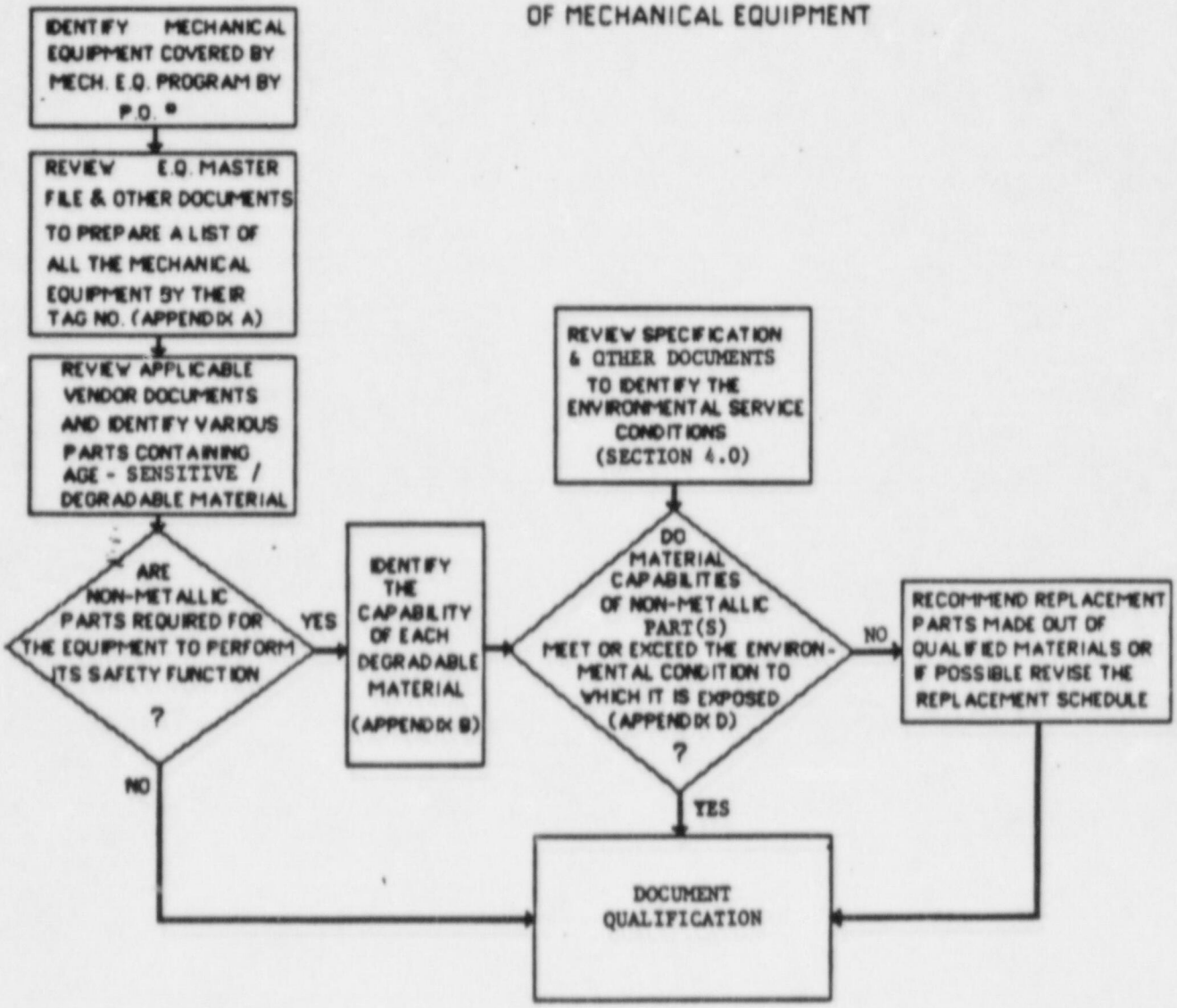
The non-metallic parts of the safety-related mechanical equipment are identified in Appendix A. Also in this Appendix the Mechanical Equipment Qualification Summary status for each part is provided. A determination is made during qualification analysis in Appendices A and D as to whether the non-metallic part is required for the equipment to perform its safety function. If a part is not required, no further analysis is performed and the rationale is provided. If the part is required, it must be constructed of materials with the capabilities to withstand the environment and process condition imposed on it. The non-metallic part's degradation must not prevent the equipment from performing its safety functions during its exposure to these environmental conditions.

Material capabilities are compared against the environmental and process effects of radiation, temperature, and aging, to determine part susceptibility. The Arrhenius equation is used where applicable to calculate the life of materials. The effects of pressure and humidity were not analyzed since these are enveloped by the process conditions given in the design specification. The effect of external beta radiation is considered to be insignificant as the non-metallic parts are shielded.

The non-metallic material qualification in Appendix D shows the results of the material capability analysis, and the qualified life of each non-metallic material. The life calculation is based on the radiation and temperature only and must be used in conjunction with the specified maintenance/surveillance program identified in equipment manual provided by respective vendor/ manufacturer.

A flow diagram of the overall approach for mechanical equipment qualification is shown on P. 5.2.

FLOW DIAGRAM OF ENVIRONMENTAL QUALIFICATION OF MECHANICAL EQUIPMENT



EQ MASTERFILE LIST

TAG NUMBER	DESCRIPTION	E M	SYS	BLDG/ ROOM	-ELEV- FT	IN	MANUFACTURER	MODEL NUMBER	H/ /M	STATUS EQ	IN
3V101VDA113	TORNADO DAMPER 132X106	M	VE	M326	091	11	AMERICAN WARM.	NBD-70	H	A	A
3V101VDA118	TORNADO DAMPER 252X144	M	HM	M324	060		AMERICAN WARM.	NBD-71	M	A	A
3V101VDA119	TORNADO DAMPER 264X144	M	HM	M324	060		AMERICAN WARM.	NBD-71	M	A	A
3V101VDA120	TORNADO DAMPER 158X141	M	HM	M324	060		AMERICAN WARM.	NBD-71	M	A	A
3V101VDA173	TORNADO DAMPER 27X27	M	HM	M324	087		AMERICAN WARM.	NBD-70	M	A	A
3V101VDA222	BACKDRAFT DAMPER 14X16	M	HM	M327A	060		AMERICAN WARM.	NBD-53	H	A	A
3V101VDA223	BACKDRAFT DAMPER 14X16	M	HM	M327A	060		AMERICAN WARM.	NBD-53	H	A	A
3V111VDA075	TORNADO DAMPER 72X48	M	HZ	M501	080		AMERICAN WARM.	NBD-71	M	A	A
3V111VDA076	TORNADO DAMPER 54X72	M	HE	M502B	086		AMERICAN WARM.	NBD-70	H	A	A
3V111VDA077	TORNADO DAMPER 48X48	M	HE	M502B	096		AMERICAN WARM.	NBD-70	H	A	B
3V111VDA078	TORNADO DAMPER 48X48	M	HE	M502B	096		AMERICAN WARM.	NBD-71	H	A	B
3V111VDA206	PARALLEL BLADE DAMPER 72X30	M	HE	M104B	020	06	AMERICAN WARM.	NVC-41	H	A	A
3V111VDA207	PARALLEL BLADE DAMPER 72X30	M	HE	M206B	053		AMERICAN WARM.	NVC-41	H	A	A
3V111VDA208	PARALLEL BLADE DAMPER 72X30	M	HE	M410	070	06	AMERICAN WARM.	NVC-41	H	A	A
3V111VDA209	OPPOSED BLADE DAMPER 72X72	M	HE	M104B	020	06	AMERICAN WARM.	NVC-41	H	A	A
3V111VDA210	OPPOSED BLADE DAMPER 72X72	M	HE	M206B	046	06	AMERICAN WARM.	NVC-41	H	A	A
3V111VDA211	OPPOSED BLADE DAMPER 72X72	M	HE	M410	071	06	AMERICAN WARM.	NVC-41	H	A	A
3V111VDA212	PARALLEL BLADE DAMPER 72X30	M	HE	M104B	020	06	AMERICAN WARM.	NVC-41	H	A	A
3V111VDA213	PARALLEL BLADE DAMPER 72X30	M	HE	M206B	046	06	AMERICAN WARM.	NVC-41	H	A	A
3V111VDA214	PARALLEL BLADE DAMPER 72X30	M	HE	M410	071	06	AMERICAN WARM.	NVC-41	H	A	B
3V111VDA215	BACKDRAFT DAMPER 18X18	M	HE	M104B	020	06	AMERICAN WARM.	NBD-53	H	A	A
3V111VDA216	BACKDRAFT DAMPER 18X18	M	HE	M206B	045	06	AMERICAN WARM.	NBD-53	H	A	A
3V111VDA217	BACKDRAFT DAMPER 18X18	M	HE	M410	071	05	AMERICAN WARM.	NBD-53	H	A	A
3V111VDA218	BACKDRAFT DAMPER 50X50	M	HE	M104B	020	06	AMERICAN WARM.	NBD-53	H	A	A
3V111VDA219	BACKDRAFT DAMPER 50X50	M	HE	M206B	048	11	AMERICAN WARM.	NBD-53	H	A	A
3V111VDA220	BACKDRAFT DAMPER 50X50	M	HE	M410	073	00	AMERICAN WARM.	NBD-53	H	A	B
3V111VDA224	BACKDRAFT DAMPER 88X36	M	HE	M104B	025	09	AMERICAN WARM.	NBD-53	H	A	A
3V111VDA225	BACKDRAFT DAMPER 88X36	M	HE	M206B	050	03	AMERICAN WARM.	NBD-53	H	A	A
3V111VDA226	BACKDRAFT DAMPER 88X36	M	HE	M410	075	09	AMERICAN WARM.	NBD-53	H	A	B
3V111VDA230	OPPOSED BLADE DAMPER 12X12	M	HB	M508	089		AMERICAN WARM.	NVC-42	H	A	A
3V111VDA231	OPPOSED BLADE DAMPER 12X12	M	HB	M507	090	07	AMERICAN WARM.	NVC-42	H	A	A
3V111VDA232	OPPOSED BLADE DAMPER 12X12	M	HB	M509	087	06	AMERICAN WARM.	NVC-42	H	A	A
3V111VDA249	OPPOSED BLADE DAMPER 30X32	M	HB	M013	016	05	AMERICAN WARM.	NVC-41	M	A	A
3V111VDA250	OPPOSED BLADE DAMPER 30X32	M	HB	M206	041		AMERICAN WARM.	NVC-41	M	A	A
3V111VDA251	OPPOSED BLADE DAMPER 30X32	M	HB	M307	066		AMERICAN WARM.	NVC-41	M	A	A
3V111VDA252	BACKDRAFT DAMPER 40X24	M	HB	M013	012	08	AMERICAN WARM.	NBD-53	H	A	A
3V111VDA253	BACKDRAFT DAMPER 40X24	M	HB	M206	037	08	AMERICAN WARM.	NBD-53	H	A	A
3V111VDA254	BACKDRAFT DAMPER 40X24	M	HB	M307	066		AMERICAN WARM.	NBD-53	H	A	A
3V111VDA258	PARALLEL BLADE DAMPER 20X20	M	HB	M013	017	10	AMERICAN WARM.	NVC-42	M	A	A
3V111VDA259	PARALLEL BLADE DAMPER 20X20	M	HB	M206	042		AMERICAN WARM.	NVC-42	M	A	A
3V111VDA260	PARALLEL BLADE DAMPER 20X20	M	HB	M307	067		AMERICAN WARM.	NVC-42	M	A	A
3V111VDA261	BACKDRAFT DAMPER 30X32	M	HB	M013	015	03	AMERICAN WARM.	NBD-53	H	A	A
3V111VDA262	BACKDRAFT DAMPER 30X32	M	HB	M206	040	03	AMERICAN WARM.	NBD-53	H	A	A
3V111VDA263	BACKDRAFT DAMPER 30X32	M	HB	M307	065	02	AMERICAN WARM.	NBD-53	H	A	A
3V111VDA264	OPPOSED BLADE DAMPER 24X24	M	HB	M013	016	07	AMERICAN WARM.	NVC-42	H	A	A
3V111VDA265	OPPOSED BLADE DAMPER 24X24	M	HB	M206	041	07	AMERICAN WARM.	NVC-42	H	A	A
3V111VDA266	OPPOSED BLADE DAMPER 24X24	M	HB	M307	066	07	AMERICAN WARM.	NVC-42	H	A	A
3V111VDA269	BACKDRAFT DAMPER 12X12	M	HB	M206	050	04	AMERICAN WARM.	NBD-53	H	A	A

SECTION 3 -Purchase Order No. & Equipment Description

SOURCE: MEQ-1

PURCHASE ORDER	EQUIPMENT DESCRIPTION	SPECIFICATION NO.
4056	Essential Cooling Water Self Cleaning	3R289NS0036-0
4062	SS Pool Gate System	3F269SS0034-1
4076	ECW Pump Lube Strainers	3R289NS0037-E
4092	Essential CLG Water Traveling Screens	3R289NS0035-E
4099	Air Handling Units	3V259VS0005-1
4102	Refrigeration	3V249VS0004-0
4113	Metallic Expansion Joints	5L359PS0505-3
4119	Safety Class Fans	3V229VS0002-3
4120	Safety Class Fans	3V229VS0002-3
4122	Miscellaneous Pumps & Motors	3Q089NS0001-0
4129	Safety Class Part Filters & Control Panels	3V239VS0003-2
4168	Safety Class Dampers	3V289VS0008-3
4308	Pulsation Dampeners for Pumps	2R179MS1012-1

SECTION 4- Environmental Conditions

SOURCE: MEQ-1

PO Number	Ambient Environmental Conditions				Reference
	Temperature (F)		r-Radiation (Rad)		
	Normal	Accident	Normal	Accident	
4076/8076	34-104	104: 0-30days	1.0E02	1.0E02	3R289NS0037-0
4092/8092	34-104	104: 0-30days	1.0E02 Note 1	1.0E02 Note 1	4E019NQ1009-6
4099/8099	50-135	155: 0.2-99sec 150: 99.1-600sec 135: 640s-30days	1.0E07	7.2E06	3V259VS0005-1 Note 9
4102/8102	50-120	125:0-10min 115:14min	1.0E03	1.3E02	3V249VS0004-1 4E019NQ1009-6
4113/8113*					
4119/8119	50-104	120	1.0E03	1.3E04	Note 9
4120/8120	50-120	335 (Max) See Fig.4.2	3.5E04	2.3E07 (Ref.180)	Note 9
4122/8122	50-104	125: 2.7-600sec 104: 4010sec	2.0E03	1.0E02	Note 9
4129/8129	50-104	120: 0-30days	1.0E03	1.3E04	3V239VS0003-3
4168/8168 (Inside the RCB)	65-120	323 (Max) See Fig.4.1	3.5E04 Note 5	2.3E07 Note 5 Ref.180	3V289VS0008-3 w/damper data sheets Note 9
4168/8168 (Outside the RCB)	29-120	120 0-30 days	1.0E03	1.7E06	3V289VS0008-3 w/damper data sheets Note 9
4308/8308	50-135	155: 0.2-99sec 150: 99.1-600sec 135: 640s-30days	1.0E07	1.0E02	2R179MS1012-2 4E019NQ1009-6
4310/8310	50-120	125:0-10min 115:14 min	1.0E03	1.3E02	3V249VS1007-3 4E019NQ1009-6

* No safety related organic/non-metallic components (Ref. 164)

NOTES:

1) The Essential CLG Water Travelling Screens are located in the essential cooling water intake structure. The environmental conditions therefore are obtained from 4E019NQ1009-Rev. 7.

2) Deleted.

3) There are two (2) areas outside the containment as specified by 4E019NQ1009-7 which are exposed to more than 1.0E07 rads (gamma only) for normal range 40 years total integrated dose (TID). These rooms in building MAB are:

	Room
a) High Activity Spent Resin Storage Tank	0054
b) Mixed Bed Demineralizer Cubicles	244A-T

Since no tag No. was identified in Rooms 0054 & 244A-T (Refer to EQ master file listing dated 6/26/86). The worst case normal radiation of 2.0E07 Rads (for inside RCB except reactor cavity rooms) is used as a conservative normal radiation level for the qualification of inside and outside RCB.

4) (Deleted)

5) The environmental conditions for the safety-related dampers with no actuators in P.O. 4168/8168 are listed. The environmental conditions for the safety-related dampers with Hiller pneumatic actuators, Model 6SA Series are:

	Temperature	Radiation
Normal:	29-120°F	1000 Rads
Accident:	120°F	4300 Rads

The environmental conditions for the safety-related dampers with Borg-Warner modulating hydraulic actuators, Models RMH-FC and ROH-FC are:

	Temperature	Radiation
Normal:	50-104°F	1000 Rads
Accident:	120°F	13,000 Rads

NOTES:

6) (Deleted)

7) For the outside containment radiation of 1.0E07 Rads is the worst case for all locations except rooms 0054 and 244A-T.

8) The turbine-driven pump and its associated equipment shall be qualified for the environmental conditions existing when cubicle ventilation has been lost. For this state of operation, this equipment must be qualified for the temperature rising from a steady temp. of 104°F to 140°F in a 30-minute period and continuing to increase at the rate of 15°F/Day for a period of 2 days once every 8 years, and excursions of 130°F for a duration of 24 hours once a year (Ref. 3S149MS0043, Rev.3).

9) The environmental conditions were determined per EQ Master File Listing and Design Criteria (4E019NQ1009, Rev. 7) for the specific room where the equipment is located.

10) Worst case harsh environmental conditions enveloping all areas in IVC cubicles (excluding accident condition), EAB, DGB, MAB rooms 18, 18A, 33, 39 and 62, Fuel Handling Building and Control Room (Inaccessible Areas).

11) In Fuel Handling Building, radiation exposure of 40-year normal operation and 180-day post accident are 2.0E03 Rads and 8.0E06 Rads respectively.

APPENDIX A

(Definition of symbols & determination of Qualified Life. Taken From MEQ-1 pages A-1 & A-2)

APPENDIX A

The following are the definitions of some of the headings, abbreviations, and symbols used in this appendix:

CONVENTION	FORM APPEARED IN APPENDIX "A"	DEFINITION
		ACCEPTABLE
-------	accept; ACCEPT	
STATIC +	Sta, S, s	The part containing the degradable material operates on static mechanical clearance (non-moving surfaces).
DYNAMIC +	Dyn, D, d	The part containing the degradable material operates on dynamic mechanical clearance (moving surfaces).
-----	UNDER REVIEW; U.R.	The information is still under review and will be resolved on the next revision.
-----	fcn	Function
-----	NMQ #	Non-metallic Qualification Data Sheet (shown in Appendix D).
-----	Q.L.	Qualified Life x
Item No.	Item #	Fictitious number assigned when material requisition Item No. not available.
	SEE ALT	The manufacturer recommendation material is not qualified use recommended alternative material.
	Ref. Document (e.g. 01003AFC)	Ref. document numbers shown in this Appendix A are for Unit 1 equipment unless otherwise noted.

x See page A-2

+ Table Heading

APPENDIX A

The qualified life is either a calculated life based on the radiation and temperature capabilities shown on the material data sheet (MDS) or the life extracted from the reports listed below. If both are available, the more conservative life is used. The qualified life must be used in conjunction with the specified maintenance/surveillance program identified in equipment manual provided by respective vendor/manufacturer.

4026EQ1-00001-DUL	4027EQ2-00008-BUP	4028-00073-AHM
4029EQ-00004-AHA	4030EQ1-00001-BUL	4030EQ-00007-BXD
4031EQ-00001-BAG	4032EQ1-00001-BUL	4037EQ-00001-AML
4039EQ-00002-BBG	4409-00257-CVT	4409-00245-AVT
4409-00244-BVT	4409-00243-AVT	4409-00207-CVT
4409-00206-BVT	4409-00204-CVT	4409-00203-CVT
4409-00201-CVT	4409-00200-BVT	4409-00199-BVT
4409-00193-CVT	4409-00192-AVT	6360-00022-BFV
6378-00090-CDA	6380-00019-AZD	6381-00024-CJL
6412-00024-CDZ	6413-00044-BFR	6452-00002-AOI
6455-00025-BQY	6373-00068-ANY	0387EQ(1)-00001-GUL 0011(1)-00158-CPD
4018-00003-BSC	4022EQ1-00001-BHT	4040EQ1-00001-BHY
4053-00016-BBT	40556EQ1-00002-BUL	40706EQ1-00001-BUL
4092EQ1-00001-CUL	4099 -00105-BAN	4122EQ1-00001-BHX
4129-00116-AMN	4168-00267-BVA	4310-00182-AYD
4315-00110-BIQ	4318-00035-DJJ	4390-00057-CYN

2

APPENDIX A

(Specific page in Appendix A for Tag Number 3V101VDA222)

SOURCE: MEQ-1

PURCHASE ORDER: 4168/8168
EQUIPMENT: DAMPERS

APPENDIX A
SOUTH TEXAS PROJECT
MECHANICAL EQUIPMENT QUALIFICATION

REVISION 1
ORIGINATOR [illegible] DATE 10/31/86
CHECKED [illegible] DATE 11/1/86

Tag No. Item No.	Component Descrip.	SUB-COMPONENT DATA: Degradable Part & Cat.No.	Part Material	Fcn Sta/ Dyna	Ref. Document	Maintenance Replacement Requirements	MAT'L QUAL DATA: Matl Qual Ref. Doc.	Qual. Status	Recommended Alternative Material	Remarks
3V101VDA052	SAFETY	EPDM-1 BULB	ETHYLENE	DYN	00267BVA	Q.L. 15 YRS	NMQ #106	ACCEPT		NOTE 1 AND FOR
3V101VDA113	CLASS	SEAL BLADE EDG	PROPYLENE							OUTSIDE
3V101VDA118	DAMPERS	SEAL MCL#7395	DICONJ.MONMR							CNTNMNT ONLY
3V101VDA119	(NVC-42	----------	----------	----		----------	---------	--------	----------	----------
3V101VDA120	NBD-53	VITON O-RING	FLUROCARBON	STA		Q.L. 8 YEARS	NMQ#135	ACCEPT		OUTSIDE CONTAI
3V101VDA173	NBD-70 &	2116-V88475,	(VITON)							NMENT APPLICAT
→ 3V101VDA222	NBD-71)	2214-",2218-"								ION ONLY
3V101VDA223		----------	----------	----		----------	---------	--------	----------	----------
3V102VDA052		EPT-4 WEDGE	ETHLYN/PROPY	DYN		Q.L. 5 YEARS	NMQ#106	ACCEPT		OUTSIDE CONTAI
3V102VDA113		SEAL W/DRYBCK	LYN/TERPLYMR							NMENT APPLICAT
3V102VDA118		ADHSV/MCL#7408	CLSD CL SPNG							ION ONLY
3V102VDA119		----------	----------	----		----------	---------	--------	----------	----------
3V102VDA120		EPDM3 BLB W/3M	ETHLYN/PROPY	DYN		Q.L. 5 YEARS	NMQ#106	ACCEPT		OUTSIDE CONTAI
3V102VDA173		SCTCHGRP 1300	LYN/DI-CONJU							NMENT APPLICAT
3V102VDA222		ADHSV MCL#7404	GATD MONOMER							ION ONLY
3V102VDA223		----------	----------	----		----------	---------	--------	----------	----------
3V111VDA075		EPT RECTNGLR	ETHLYN/PROPY	STA		Q.L. 20 YEARS	NMQ#106	ACCEPT		DMPR TG#S USED
3V111VDA076		SPNG FLNG GSKT	LYN/TRPOLYMR							3V121/122VDA,
3V111VDA077		RUBATEX R495T								163,164,165
3V111VDA078		----------	----------	----		----------	---------	--------	----------	----------
3V111VDA215		GE RTV-106	SILICON	STA		Q.L. 10 YEARS	NMQ#132	ACCEPT		
3V111VDA216		SILICONE SEAL								
3V111VDA217		COMPOUND								
3V111VDA218		----------	----------	----		----------	---------	--------	----------	----------
3V111VDA219		BALL BEARING	WOOL FELT &	DYN		NOTE 2	NOTE 2	NOTE 2		OUTSIDE CONTA-
3V111VDA220		ASSEMBLY FLNGR	POLYAMIDE							INMENT APPLIC-
3V111VDA224		&NYLON COATING	(NYLON)							ATION ONLY
3V111VDA225		----------	----------	----		----------	---------	--------	----------	----------
3V111VDA226										
3V111VDA252										
3V111VDA253										
3V111VDA254										
3V111VDA261										
3V111VDA262										
3V111VDA263										
3V111VDA264										
3V111VDA265										
3V111VDA266										
3V111VDA269										
3V111VDA275										
3V111VDA276										
3V111VDA277										
3V111VDA286										
3V111VDA287										
3V111VDA288										
3V111VDA289										

PURCHASE ORDER 4168/8168
EQUIPMENT DAMPERS

APPENDIX A
SOUTH TEXAS PROJECT
MECHANICAL EQUIPMENT QUALIFICATION

SHEET 8 OF 8
REVISION 1
ORIGINATOR RLS DATE 10/31/86
CHECKED NP DATE 11/1/86

NOTE: 1. Unit 2 tag nos. have not been checked against the latest Unit 2 EQ Masterfile Listing.

2. Sealmaster Relubricable Ball Bearing with Wool Felt Seal Nylon coated steel ball retainer 90° grease fitting and Shell Alvania No. 2 grease. These materials are qualified to outside containment application. Refer to 4168-00267-BVA P.8 and P.55.

3. The EPT-4 jamb (wedge) seal was to be replaced by a metallic seal which was unaffected by the environmental parameters. Modified dampers are Model NBD-53, damper tag nos. 3V141VDA-165 through -168 and 3V142VDA-165 through 168. (Refer to 4168-00267-BVA, page 370/Section 9.0)

4. The EPDM-3 would maintain its functionality if mechanically fastened as well as adhesively bounded for use inside containment. (Refer to 4168-00267-BVA, page 370/Section 9.0).

APPENDIX A1

LUBRICATION FOR SAFETY RELATED

DAMPERS

SOURCE : MEQ -1

PURCHASE ORDER: 4168/8168
EQUIPMENT: DAMPERS

APPENDIX A1
SOUTH TEXAS PROJECT
MECHANICAL EQUIPMENT QUALIFICATION

SHEET 1 OF 3
REVISION 1
ORIGINATOR [illegible] DATE 10/31/86
CHECKED MF DATE 11/3/86

Item Nos. (Refer to Appendix A for the Tag No. listings)	Component Descrip.	SUB-COMPONENT DATA: Lubricant for: Part &/or Cat#	Lubricant:	Fcn Sta/ Dyna	Ref. Document	MAT'L QUAL DATA: Matl Qual Ref. Doc.	Qual. Status	Gulf Oil Co. Recommended Alternative	Remarks
	SAFETY CLASS DAMPERS (MANUALLY	BRONZE SLEEVE BEARINGS AND LINKAGE PIVOTS	LIGHT OIL SAE 10-30 Wt nonDetergent	DYN	00026 00029 00262 00243	USE ALT	SEE ALT	GULF HARMONY #68 (NMQ#53)	NOTE 1
		BACK DRAFT DAMPERS - BALL BEARINGS	ALVANIA #2 (OUTSIDE CONTAINMENT)	DYN		NMQ#72	ACCEPT.	GULF CROWN #2 (NMQ#47)	NOTE 1
		BACK DRAFT DAMPERS - BALL BEARINGS	DOW CORNING DC-41 (IN. CONTAINMENT)	DYN		NMQ#22	ACCEPT.	GULF HIGH TEMP. GREASE (NMQ#53E)	NOTE 1
		DAMPER O-RING	'VASELINE' PETROLEUM JELLY	STA		NOT REQ'D	N/A	NONE	NON SAFETY (REF. 163) (REASSEMBLY)
	SAFETY CLASS DAMPERS W/ HILLER PNEUMATIC ACTUATORS	BRONZE SLEEVE BEARINGS AND LINKAGE PIVOTS	LIGHT OIL SAE 10-30 Wt nonDetergent	DYN	00026 00029 00262 00243	USE ALT	SEE ALT	GULF HARMONY #68 (NMQ#53)	NOTE 1
		BACK DRAFT DAMPERS - BALL BEARINGS	ALVANIA #2 (OUTSIDE CONTAINMENT)	DYN		NMQ#72	ACCEPT.	GULF CROWN #2 (NMQ#47)	NOTE 1
		HILLER PNEU ACT'RS-MDL 6SA a)O-RINGS	DOW CORNING #33	DYN		NMQ#20	ACCEPT.	NONE	
		b)ROD WIPER, ROD PACKING, & PISTON PACKING	DOW CORNING #33	DYN		NMQ#20	ACCEPT	NONE	
		c)O.D. PISTON AND TUBE	DOW CORNING M77	DYN		NMQ#21	ACCEPT	NONE	NOTE 1
		d)SEALANT - PIPE THREAD	LOCTITE HYDRAULIC SEALANT#569	STA		NMQ#60	ACCEPT	NONE	REASSEMBLY
		e)THREAD LOCK-PISTON ROD ASSEMBLY	LOCTITE PRIMER GR. T & No.277	STA		NMQ#60A	ACCEPT	NONE	REASSEMBLY

PURCHASE ORDER 4168/8168
EQUIPMENT DAMPERS

APPENDIX A1
SOUTH TEXAS PROJECT
MECHANICAL EQUIPMENT QUALIFICATION

SHEET 3 OF 3
REVISION 1
ORIGINATOR [illegible] DATE 10/31/86
CHECKED MF DATE 11/3/86

NOTE: 1. Reference 82B provides Gulf Oil Co.'s recommendations of alternative Gulf lubricant replacements, if any. The original equipment manufacturer has yet to approve or disapprove the Gulf alternatives.

APPENDIX C

(Specific pages in the Non-Metallic Qualification for material identified in the equipment)

SOURCE: MEQ-1

STP NMQ # 22
SHEET 1 of 1
REVISION 1
ORIG. [illegible] DATE 10/31/86
CHKD. MF DATE 11/3/86

APPENDIX C
SOUTH TEXAS PROJECT
MECHANICAL EQUIPMENT QUALIFICATION PROGRAM
NON-METALLIC MATERIAL QUALIFICATION

MATERIAL: MOLYKOTE M-#41 GREASE FROM DOW CORNING

MATERIAL DATA SHEET: MDS - 22

ASSOCIATED
P.O.: 4034/8034;4168/8168

SYSTEM MEDIA: Air

QUALIFICATION: LUBRICANT OF BALL BEARINGS OF BACKDRAFT DAMPERS ACTUATORS INSIDE THE CONTAINMENT. THE QUALIFICATION PARAMETERS ARE SUMMARIZED BELOW.

PARAMETERS	ENVELOPING ENVIRONMENTAL CONDITION	MATERIAL CAPABILITIES/ QUALIFICATIONS	REMARKS
TEMPERATURE (F)	NORMAL: 29 - 120 ACCIDENT PROFILE: 170, 1.0 sec 323, 10 - 200 sec 280, 500 - 5000 sec 170, 1 day 140, 1 - 11 days 120, 11 - 30 days	-31 TO 550F	
OPERABILITY TIME	PROCESS: AMBIENT ENVIRONMENT 30 days		
RADIATION (RADS)	NORMAL: 2.0E07 ACCIDENT: 2.3E07 INTERNAL:	5.0E08	SAME AS THE AMBIENT ENVIRONMENT

MAINTENANCE
REPLACEMENT
RECOMMENDATIONS: FOLLOW THE ORIGINAL EQUIPMENT MANUFACTURER'S REPLACEMENT RECOMMENDATIONS AS STATED IN APPENDIX A1.

CONCLUSIONS: The radiation damage threshold far exceeds the requirements, and is not considered radiation sensitive for the specified enviroment. Since the thermal capability also far exceeds the requirement, the lubricant is not considered temperature sensitive for the specified environment. For P.O. 4034/8034, lubricant is used in reassembly only, and does not perform any safety function. Therefore, this lubricant is qualified for this plant specific application.

STP NMQ # 47
SHEET 1 of 2
REVISION 1
ORIG. [illegible] DATE 10/31/86
CHKD. MF DATE 11/3/86

APPENDIX C

SOUTH TEXAS PROJECT
MECHANICAL EQUIPMENT QUALIFICATION PROGRAM
NON-METALLIC MATERIAL QUALIFICATION

MATERIAL: GULFCROWN GREASE FROM GULF OIL CO.

MATERIAL DATA SHEET: MDS - 47

ASSOCIATED
P.O.: 4000/8000;4027/8027;4029/8029;4038/8038;4041/8041;4092/8092;4122/8122; 4168/8168;4315/8315;4409/8409

SYSTEM MEDIA: Air

QUALIFICATION: LUBRICANT USED ON BEARINGS. THE QUALIFICATION PARAMETERS ARE SUMMARIZED BELOW.

PARAMETERS	ENVELOPING ENVIRONMENTAL CONDITION	MATERIAL CAPABILITIES/ QUALIFICATIONS	REMARKS
TEMPERATURE (F)	NORMAL: 29 - 135	10 TO 250F	
	ACCIDENT PROFILE:		
	290, 0.5 sec		
	335, 20-400 sec	379 DROPPING PT.	SEE REFERENCE 246,
	324, 400 sec-0.5hr		ACCEPTABLE
	203, 1 hr-7 days		
	104, 7-30 days		
	PROCESS: 200F		(SEE NOTE)
OPERABILITY TIME	30 days		
RADIATION (RADS)	NORMAL: 2.0E07	2.0E08 RADS	
	ACCIDENT: 2.3E07		
	INTERNAL:		NOT IN CONTACT WITH THE PROCESS FLUID (REF. 198)

MAINTENANCE
REPLACEMENT
RECOMMENDATIONS: FOLLOW THE ORIGINAL EQUIPMENT MANUFACTURER'S REPLACEMENT RECOMMENDATIONS AS STATED IN APPENDIX A1.

CONCLUSIONS: The radiation damage threshold far exceeds the requirements, and is not considered radiation sensitive for the specified environment. Since the thermal capability also far exceeds the requirement, the lubricant is not considered temperature sensitive for the specified environment. Therefore, this lubricant is qualified for this plant specific application.

NOTES: Based on the above P.O.'s, the process temperature that the lubricant for the Limitorque Valve operator will be exposed to are: 200°F per 4041/8041, 120°F per the "RA" system of 4029/8029, 135°F per 4032/8032 (See telecon E003034, Ref. 165) & 130°F per 4038/8038. Therefore, the maximum process temperature the lubricant will experience is 200°F.

STP NMQ # 53
SHEET 1 of 1
REVISION 1
ORIG. [illegible] DATE 10/31/[illegible]
CHKD. MF DATE 11/3/8[illegible]

APPENDIX C

SOUTH TEXAS PROJECT
MECHANICAL EQUIPMENT QUALIFICATION PROGRAM
NON-METALLIC MATERIAL QUALIFICATION

MATERIAL: GULFHARMONY #68 FROM GULF OIL CO.

MATERIAL DATA SHEET: MDS - 53

ASSOCIATED
P.O.: 0011(1) &
0011(2);4000/8000;4014/8014;4040/8040;4041/8041;4053/8053;4168/8168

SYSTEM MEDIA: Air

QUALIFICATION: LUBRICANT USED ON THE DAMPER BEARINGS & LINKAGE PIVOTS, AC GENERATOR BEARINGS AND THE MOTOR BEARINGS OF THE ECW PUMPS. THE QUALIFICATION PARAMETERS ARE SUMMARIZED BELOW.

PARAMETERS	ENVELOPING ENVIRONMENTAL CONDITION	MATERIAL CAPABILITIES/ QUALIFICATIONS	REMARKS
TEMPERATURE (F)	NORMAL: 29 - 135 ACCIDENT PROFILE: 290, 0.5 sec 335, 20-400 sec 324, 400 sec-0.5hr 203, 1 hr-7 days 104, 7-30 days PROCESS: 200F	40 TO 130F 450F FLASH PT.	 ACCEPTABLE FOR TRANSIENT TEMPERATURE NOT TO EXCEED 85% OF FLASH PT. (REF. 246)
OPERABILITY TIME	30 days		
RADIATION (RADS)	NORMAL: 2.0E07 ACCIDENT: 2.3E07 INTERNAL:	1.0E08 RADS	 SAME AS THE AMBIENT ENVIRONMENT.

MAINTENANCE
REPLACEMENT
RECOMMENDATIONS: FOLLOW THE ORIGINAL EQUIPMENT MANUFACTURER'S REPLACEMENT RECOMMENDATIONS AS STATED IN APPENDIX A1.

CONCLUSIONS: The radiation damage threshold far exceeds the requirements, and is not considered radiation sensitive for the specified environment. Since the thermal capability also far exceeds the requirement, the lubricant is not considered temperature sensitive for the specified environment. Therefore, this lubricant is qualified for this plant specific application.

STP NMQ # 53E
SHEET 1 of 1
REVISION 1
ORIG. [illegible] DATE 10/31/86
CHKD. MF DATE 11/3/86

APPENDIX C
SOUTH TEXAS PROJECT
MECHANICAL EQUIPMENT QUALIFICATION PROGRAM
NON-METALLIC MATERIAL QUALIFICATION

MATERIAL: GULF HIGH TEMPERATURE GREASE FROM GULF OIL CO.

MATERIAL DATA SHEET: MDS-53E

ASSOCIATED
P.O.: 0011(1) & (2);4000/8000;4027/8027;4034/8034;4041/8041;4168/8168

SYSTEM MEDIA: Air

QUALIFICATION: LUBRICANT IS USED AS THE ALTERNATIVE LUBRICANT FOR THE BOTTOM BLOCK SHEAVE BEARINGS AND UPPER SHEAVE BEARINGS OF THE EQUALIZER FOR THE EQUIPMENT HATCH. ALSO USED AS THE ALTERNATIVE LUBRICANT IN THE INTERNAL PARTS OF THE MECHANICAL & INTERLOCK SYSTEM OF THE AUXILIARY AIR LOCK. THE QUALIFICATION PARAMETERS ARE SUMMARIZED BELOW..

PARAMETERS	ENVELOPING ENVIRONMENTAL CONDITION	MATERIAL CAPABILITIES/ QUALIFICATIONS	REMARKS
TEMPERATURE (F)	NORMAL: 29 - 135 ACCIDENT PROFILE: 290, 0.5 sec 335, 20-400 sec 324, 400sec-0.5hr 203, 1 hr-7 days 104, 7-30 days	0 TO 325F 568F DROPPING POINT	SEE REFERENCE 246, ACCEPTABLE
OPERABILITY TIME	PROCESS: AMBIENT ENVIRONMENT 30 days		
RADIATION (RADS)	NORMAL: 2.0E07 ACCIDENT: 2.3E07 INTERNAL:	1.0E08 RADS	NOT IN CONTACT WITH THE PROCESS FLUID (REF. 198)

MAINTENANCE
REPLACEMENT
RECOMMENDATIONS: FOLLOW THE ORIGINAL EQUIPMENT MANUFACTURER'S REPLACEMENT RECOMMENDATIONS AS STATED IN APPENDIX A1.

CONCLUSIONS: The radiation damage threshold far exceeds the requirements, and is not considered radiation sensitive for the specified environment. Since the thermal capability also far exceeds the requirement, the lubricant is not considered temperature sensitive for the specified environment. Therefore, this lubricant is qualified for this plant specific application.

APPENDIX C

STP NMQ # 72
SHEET 1 OF 1
REVISION 1
ORIG. [illegible] DATE 10/31/86
CHKD. MF DATE 11/3/86

SOUTH TEXAS PROJECT
MECHANICAL EQUIPMENT QUALIFICATION PROGRAM
NON-METALLIC MATERIAL QUALIFICATION

MATERIAL: ALVANIA #2 GREASE FROM SHELL

MATERIAL DATA SHEET: MDS - 72

ASSOCIATED
P.O. 4014/8014:4119/8119;4168/8168

SYSTEM MEDIA: Air

QUALIFICATION: LUBRICANT USED IN THE DAMPER BEARINGS & MOTOR BEARINGS. THE QUALIFICATION PARAMETERS ARE SUMMARIZED BELOW.

PARAMETERS	ENVELOPING ENVIRONMENTAL CONDITION	MATERIAL CAPABILITIES/ QUALIFICATIONS	REMARKS
TEMPERATURE (F)	NORMAL: 65 - 120 ACCIDENT PROFILE: 323, 10 - 100 sec 280, 500 - 5000 sec 185, 1 day 75, 11 days 120, 30 days	-30 TO 275F 365F DROPPING POINT	SEE REFERENCE 246, ACCEPTABLE
OPERABILITY TIME	PROCESS: 165F 30 Days		
RADIATION (RADS)	NORMAL: 3.5E04 ACCIDENT: 2.3E07	2.0E08 Rads	
	INTERNAL:		SAME AS THE AMBIENT ENVIRONMENT

MAINTENANCE REPLACEMENT RECOMMENDATIONS: FOLLOW THE ORIGINAL EQUIPMENT MANUFACTURER'S REPLACEMENT RECOMMENDATIONS AS STATED IN APPENDIX A1.

CONCLUSIONS: The radiation damage threshold far exceeds the requirements, and is not considered radiation sensitive for the specified environment. Since the thermal capability also far exceeds the requirement, the lubricant is not considered temperature sensitive for the specified environment. Therefore, this lubricant is qualified for this plant specific application.

The item has been deleted from P.O. 4119/8119 since the centrifugal fans do not exist at STP.

APPENDIX C

STP NMQ #106
SHEET 4 OF 13
REVISION 2
ORIG. MT DATE 10-31-86
CHKD. NP DATE 11-1-86

3

SOUTH TEXAS PROJECT
MECHANICAL EQUIPMENT QUALIFICATION PROGRAM
NON-METALLIC MATERIAL QUALIFICATION

MATERIAL. EPT/EPDM

MATERIAL DATA SHEET: MDS #106

ASSOCIATED P.O.. 4168 (Outside RCB)

QUALIFICATION: EPDM is used as blade seal material (Mechanically fastened).

PARAMETERS	ENVELOPING ENVIRONMENTAL CONDITION	MATERIAL CAPABILITIES/ QUALIFICATIONS	REMARKS
TEMPERATURE (F)	NORMAL: 120 (Max) ACCIDENT: 120 Max PROCESS: N/A	Aging Test: 584 Hrs at 203 F (95°C)	
OPERABILITY TIME	30 Days		HVAC Damper Data Sheet (Dwg. No. 3V289V24010) & Wyle Test Report No. #47531-1)
RADIATION (RADS)	NORMAL: 1.0E03 ACCIDENT. 1.7E06 INTERNAL: 3.96E04	3.54E06	
QUALIFIED LIFE	5 years at 120°F for wedge seal (EPT) with dryback adhesive. 20 years at 120°F for flange gasket (EPT) used on damper tag Nos. 3V121/122VDA163 164, & 165 only (Ref. 4168-00267BVA). 5 years at 120°F for bulb seal (EPDM) with 3M scotchgrip 1300 adhesive. 15 years at 120°F for bulb seal (blade edge seal).		
CONCLUSIONS	Acceptable.		

NMQMF2/APPC2/18

APPENDIX C

STP NMQ # 132
SHEET 2 OF 5
REVISION 1
ORIG. NP DATE 10-31-86
CHKD. mT DATE 11-1-86

SOUTH TEXAS PROJECT
MECHANICAL EQUIPMENT QUALIFICATION PROGRAM
NON-METALLIC MATERIAL QUALIFICATION

MATERIAL: GE RTV-106 SILICONE SEALANT

MATERIAL DATA SHEET: MDS #132

ASSOCIATED P.O.: 4168

QUALIFICATION: SILICONE IS USED AS SEALING COMPOUND FOR BOTH INSIDE AND OUTSIDE CONTAINMENT APPLICATION.

PARAMETERS	ENVELOPING ENVIRONMENTAL CONDITION	MATERIAL CAPABILITIES/ QUALIFICATIONS	REMARKS
TEMPERATURE (F)	NORMAL: 120 (Max) ACCIDENT: 323(Max) PROCESS: N/A	AGING TEST 584 HRS @ 203°F (95°C)	
OPERABILITY TIME	30 DAYS		
RADIATION (RADS)	NORMAL: 3.5E04 ACCIDENT: 2.3E07 INTERNAL: 3.96E04	1.54E08	REF. WYLE TEST REPORT NO. 47531-1. (4168-00267-BVA, P.90)

QUALIFIED LIFE: 10 YEARS (REF. 4168-00267-BVA) ←

CONCLUSIONS: ACCEPTABLE

NQ121140/NQ121t140

APPENDIX C

STP NMQ # 135
SHEET 2 OF 7
REVISION 2
ORIG. NJ DATE 10-31-86
CHKD. MT DATE 11-1-86

3

SOUTH TEXAS PROJECT
MECHANICAL EQUIPMENT QUALIFICATION PROGRAM
NON-METALLIC MATERIAL QUALIFICATION

MATERIAL: VITON

MATERIAL DATA SHEET: MDS #135

ASSOCIATED P.O.: 4168

QUALIFICATION: VITON IS USED AS O-RING MATERIAL FOR OUTSIDE CONTAINMENT APPLICATION.

PARAMETERS	ENVELOPING ENVIRONMENTAL CONDITION	MATERIAL CAPABILITIES/ QUALIFICATIONS	REMARKS
TEMPERATURE (F)	NORMAL: 29-120 ACCIDENT: 120 PROCESS: N/A	400	
OPERABILITY TIME	30 DAYS		
RADIATION (RADS)	NORMAL: 1.0E03 ACCIDENT: 1.7E06 INTERNAL: 3.96E04	8.75E06 (Max. for dynamic application)	

QUALIFIED LIFE: 8 YEARS AT 120°F (REF. 14926-4168-00267-BVA).

CONCLUSIONS: ACCEPTABLE

NQ121140/NQ121t140

APPENDIX B

(Specific pages in Appendix B that address the threshold level of the material under investigation in the component)

SOURCE: MEQ-1

MATERIAL DATA SHEET

Revision 1

MATERIAL. MOLYKOTE #M-41 GREASE

GRADE, CLASS:

VISCOSITY:

MANUFACTURER(S). DOW CORNING

SHELF LIFE: 18 MONTHS

REFERENCE: 58

TEMPERATURE RESISTANCE.

MEDIUM:

OPERATING RANGE. -31 TO 550°F (USEFUL RANGE)

REFERENCE. 58 P.32

TRANSIENT:

REFERENCE.

TEMPERATURE LEVEL FOR NO DETERIORATION. (a)

THRESHOLD FOR NOTED DETERIORATION. (b)

(c)

(d)

REFERENCES. (a) (b) 58 P.32 (c) (d)

ARRHENIUS CONSTANT.

BASIS.

REFERENCE:

RADIATION RESISTANCE:

RADIATION LEVEL FOR SLIGHT DETERIORATION

GAMMA. (a)

(b)

THRESHOLD FOR NOTED DETERIORATION

(c) 500 MRADS

(d)

MATERIAL DATA SHEET (cont'd)

Revision 1

(e)

(f)

(g)

(h)

REFERENCE: (a) (b) (c) 58 P.32 (d)
(e) (f) (g) (h)

DOSE RATE EFFECTS:

REFERENCE:

SYNERGISTIC EFFECTS.

REFERENCE.

MEDIA LIMITATIONS:

REFERENCE:

NOTES. MOLYKOTE M-#41 GREASE IS A CARBON BLACK-GELLED METHYLPHENYLSILICONE AS INDICATED IN 111B. ITS RADIATION DOSAGE FOR SLIGHT DETERIORATION IS ESTIMATED TO BE 5E07 RADS AND A MAXIMUM RECOMMENDED DOSAGE OF 2E08 RADS (REFERENCE 240).

APPENDIX B

MATERIAL DATA SHEET

MDS # 47
Page Revision 1

MATERIAL: GULFCROWN GREASE

GRADE, CLASS: NLGI #2 VISCOSITY:

MANUFACTURER(S): GULF OIL CO

SHELF LIFE: REFERENCE:

TEMPERATURE RESISTANCE:

MEDIUM:

OPERATING RANGE: 10 TO 250F REFERENCE: 82 ←

TRANSIENT: 379 DROPPING POINT REFERENCE: 82 ←

TEMPERATURE LEVEL FOR
NO DETERIORATION (a)

THRESHOLD FOR NOTED DETERIORATION: (b)

(c)

(d)

REFERENCES: (a) (b) (c) (d)

ARRHENIUS CONSTANT:

BASIS:

REFERENCE:

RADIATION RESISTANCE:

RADIATION LEVEL FOR SLIGHT DETERIORATION

GAMMA (a) RESISTANT UP TO 100 MRADS.

(b) UP TO 500 MRADS, THE GREASE SHOWED LITTLE OR NO CHANGE IN OIL SEPARATION.

THRESHOLD FOR NOTED DETERIORATION

(c) AT 100 MRADS, THE GREASE CHANGED FROM LIGHT AMBER TO RED AND DARK AMBER, AND A PRONOUNCED BURNING ODOR WAS PRESENT.

(d) A DRAMATIC DECREASE IN DROPPING POINT TEMPERATURE WAS NOTED AT 250 MRADS.

(e) THE WORKED PENETRATION OF THE GREASE WAS SERIOUSLY DEGRADED AT 200 MRADS. (MAXIMUM RECOMMENDED - SEE NOTE)

(f) THE GREASE BECAME MORE ACID AS RADIATION INCREASED WITH SEVERE ACIDITY OCCURRING AT ABOUT 200 MRADS.

(g)

(h)

REFERENCE: (a) 101 p. 30 (b) 101 p. 31 (c) 101 p. 30 (d) 101 p. 31

(e) 101 p. 31 (f) 101 p. 31 (g) (h)

DOSE RATE EFFECTS:

REFERENCE:

RYNERGISTIC EFFECTS:

REFERENCE:

MEDIA LIMITATIONS:

REFERENCE:

NOTES: THE FOLLOWING DATA ARE FROM REFERENCE 101:

DOSE	DROPPING POINT	WORKED PENETRATION
5E07	Unchanged	+10%
1E08	-2%	-8%
2E08	-2%	-23%

MATERIAL DATA SHEET

MATERIAL: GULFHARMONY #68

GRADE, CLASS: AGMA #2 VISCOSITY: 323 SSU@100F

MANUFACTURER(S): GULF OIL CO

SHELF LIFE: REFERENCE:

TEMPERATURE RESISTANCE:

MEDIUM:

OPERATING RANGE: 40 TO 130F REFERENCE: 82 ←

TRANSIENT: 450F FLASH POINT REFERENCE: 82 ←

TEMPERATURE LEVEL FOR
NO DETERIORATION (a)

THRESHOLD FOR NOTED DETERIORATION: (b)

(c)

(d)

REFERENCES: (a) (b) (c) (d)

ARRHENIUS CONSTANT:

BASIS:

REFERENCE:

RADIATION RESISTANCE:

RADIATION LEVEL FOR SLIGHT DETERIORATION

GAMMA (a) RESISTANT UP TO 10 MRADS (SEE NOTE).

(b)

THRESHOLD FOR NOTED DETERIORATION

(c) AT THE 10 MRAD LEVEL SOME DETERIORATION OF RUST PROTECTION IS SEEN AS A 30% REDUCTION IN OXIDATION STABILITY.

(d) AT THE 50 MRAD LEVEL, FURTHER DETERIORATION OF RUST AND OXIDATION PROPERTIES CONTINUES. NO OTHER ADVERSE RESULTS ARE NOTED.

Revision 1

(e) AT THE 100 MRAD LEVEL,NO RUST PROTECTION REMAINS AND THE REMAINING OXIDATION INHIBITOR HAS BEEN REDUCED TO 52%. (MAXIMUM RECOMMENDED - SEE NOTE)

(f) AT THE 200 MRAD LEVEL, OXIDATION STABILITY IS ESSENTIALLY THAT OF AN UNINHIBITED OIL. ANALYSIS SHOWED ONLY 15% OF THE OXIDATION INHIBITOR REMAINS.

(g)

(h)

REFERENCE: (a) 101 p.5 (b) (c) 101 F.5 (d) 101 P.5

(e) 101 p 5 (f) 101 p.5 (g) (h)

DOSE RATE EFFECTS.

REFERENCE:

SYNERGISTIC EFFECTS.

REFERENCE.

MEDIA LIMITATIONS.

REFERENCE:

NOTES. THE RADIATION RESULTS ARE BASED ON GULFHARMONY #68 BEING SIMILAR TO GULFHARMONY #78EP AS A HARMONY CLASS OIL PER REFERENCE 82. GULFHARMONY #68 IS EXPECTED TO REACT AND HAVE THE SAME RADIATION TENDENCIES AS GULFHARMONY (REF. 82,TELECON).

DATA PERTINENT TO HARMONY #68 BUT FOR GULF HARMONY 78EP ARE FROM REFERENCE 101.

DOSE	VISCOSITY @ 100°F
1E07	+2%
5E07	+7%
1E08	+15%
2E08	+32%

MATERIAL DATA SHEET

Revision 1

MATERIAL: GULF HIGH TEMPERATURE GREASE

GRADE, CLASS: NLGI #1 VISCOSITY: 600 SUV @ 100F

MANUFACTURER(S): GULF OIL CO

SHELF LIFE: REFERENCE:

TEMPERATURE RESISTANCE:

MEDIUM:

OPERATING RANGE: 0 TO 325F REFERENCE: 82A (TEL)

TRANSIENT: 568 DROPPING POINT REFERENCE: 82A

TEMPERATURE LEVEL FOR NO DETERIOPATION (a)

THRESHOLD FOR NOTED DETERIORATION: (b)

(c)

(d)

REFERENCES: (a) (b) (c) (d)

ARRHENIUS CONSTANT:

BASIS:

REFERENCE:

RADIATION RESISTANCE:

RADIATION LEVEL FOR SLIGHT DETERIORATION

GAMMA (a)

(b)

THRESHOLD FOR NOTED DETERIORATION

(c) 50 MRADS 14% INCREASE IN DROPPING POINT
15% INCREASE IN PENETRATION

MATERIAL DATA SHEET (cont'd)

(d) 100 MRADS — 11% INCREASE IN DROPPING POINT
18% INCREASE IN PENETRATION
(MAXIMUM RECOMMENDED)

(e)

(f)

(g)

(h)

REFERENCE: (a) (b) (c) 101 p.32 (d) 101 p.32

(e) (f) (g) (h)

DOSE RATE EFFECTS:

REFERENCE:

SYNERGISTIC EFFECTS:

REFERENCE:

MEDIA LIMITATIONS:

REFERENCE:

NOTES: GULF HIGH TEMPERATURE IS A CALCIUM COMPLEX SOAP THICKENED GREASE IN MINERAL OIL (REF 82A).

THE FOLLOWING DATA ARE FROM REFERENCE 101:

DOSE	DROPPING POINT	WORKED PENETRATION
5E07	+14%	+15%
1E08	+11%	+15%
2E08	-3%	+42%

MATERIAL DATA SHEET

Revision 1

MATERIAL: ALVANIA #2 GREASE

GRADE, CLASS: NLGI #2 VISCOSITY: 515 SUS @100F

MANUFACTURER(S). SHELL

SHELF LIFE: 18 MONTHS REFERENCE: 90

TEMPERATURE RESISTANCE.

MEDIUM:

OPERATING RANGE. -30 to 275F (SEE NOTE 2) REFERENCE: 90

TRANSIENT: 365F DROPPING POINT REFERENCE: 90

TEMPERATURE LEVEL FOR NO DETERIORATION: (a)

THRESHOLD FOR NOTED DETERIORATION: (b)

(c)

(d)

REFERENCES: (a) (b) (c) (d)

ARRHENIUS CONSTANT:

BASIS.

REFERENCE:

RADIATION RESISTANCE.

RADIATION LEVEL FOR SLIGHT DETERIORATION

GAMMA. (a) 1E07 RADS (SEE NOTE 3)

(b)

THRESHOLD FOR NOTED DETERIORATION

(c) 2E08 RADS (MAXIMUM RECOMMENDED - BASED ON DATA FROM A SIMILAR GREASE, GULFCROWN).

(d) SHELL TESTED ALVANIA #2 GREASES SHOWING A 20% SOFTENING AFTER RADIATION EXPOSURE AT 4.75E08 ROENTGENS (4.1E08 RADS) IN STATIC TESTS.

(e)

(f)

(g)

(h)

REFERENCE: (a) 101 (b) (c) 101 (d) 90 ←
(e) (f) (g) (h)

DOSE RATE EFFECTS:

REFERENCE:

SYNERGISTIC EFFECTS:

REFERENCE:

MEDIA LIMITATIONS:

REFERENCE:

NOTES:

1) REFERENCE 90 INDICATES THAT ALVANIA GREASES ARE MINERAL OIL THICKENED WITH A LITHIUM 12 HYDROXYSTEARATE SOAP. THESE GREASES ARE INHIBITED WITH ADDITIVES FOR LONG SERVICE CONDITIONS. SHELL PERFORMED TESTS ON ALVANIA #2 TO 4.8E08 ROENTGENS.

2) THE OPERATING TEMPERATURE IS STATED AS A FUNCTION OF THE BEARING SPEED FACTOR (REFERENCE 90).

3) DATA PERTINENT TO ALVANIA GREASES, BUT FOR GULFCROWN GREASE ARE FROM REFERENCE 101.

DOSE	DROPPING POINT	WORKED PENETRATION
5E07	Unchanged	+10%
1E08	-2%	-8%
2E08	Unchanged	-23%
4E08	-21%	-5%

MATERIAL DATA SHEET

MATERIAL: ETHYLENE PROPYLENE ELASTOMERS

GRADE, CLASS: EPR(EPM*), EPT(EPDM*) VISCOSITY:
*ASTM Designation

MANUFACTURER(S):
SHELF LIFE: REFERENCE:
TEMPERATURE RESISTANCE: MEDIUM:
OPERATING RANGE: 90°C (194°F) REFERENCE: 176/Table 4-87/ P.4-200

TRANSIENT: 350°F REFERENCE: 177/P.272

TEMPERATURE LEVEL FOR
NO DETERIORATION (a)

THRESHOLD FOR NOTED
DETERIORATION: (b)
(c)
(d)

REFERENCES: (a) (b) (c) (d)

ARRHENIUS CONSTANT: ln (Life) = 15524.1267(1/T)-29.8774 (EPR)
ln (Life) = 17024.15987(1/T)-36.76409 (EPDM)

BASIS:

REFERENCE: 172/P.21 and P.27

RADIATION RESISTANCE:

RADIATION LEVEL FOR NO DETERIORATION

GAMMA (a) 1.0E06 Rads (Compression set)
(b)

THRESHOLD FOR NOTED DETERIORATION

(c) 1.0E07 Rads: No dynamic seals be used after radiation doses greater than 1.0E07Rads.
(d) 2.0E07 Rads: EPDM 50% compression set
(e) 4.6587E07 Rads: EPDM 70% compression set
(f) 5.0E07 Rads: EPR: -59% elongation
EPDM: -52% elongation
(g) 8.0E07 Rads: EPR: mild to moderate damage, utility is often satisfactory.
(h) 1.0E08 Rads: EPR: -10% tensile strength
EPDM: -21% tensile strength

Other than dynamic seal, EPR & EPDM are considered qualified for 4.6587E07 Rads.

MATERIAL DATA SHEET (cont'd)

REFERENCE (a)172/P.21 & P.27 (b) (c) 10/P.3-24 (d)0387EQ(1)-00001-GUL/P.43
10/P.3-24

(e)0387EQ(1)-00001-GUL/P.43 (f)10/P.3-24 (g) 172/P.11

(h)10/P.3-24

DOSE RATE EFFECTS:

REFERENCE:

SYNERGISTIC EFFECTS:

REFERENCE:

MEDIA LIMITATIONS:

REFERENCE:

NOTES:

MATERIAL DATA SHEET

MATERIAL: SILICONE RUBBER

GRADE, CLASS: VISCOSITY:

MANUFACTURER(S):

SHELF LIFE: REFERENCE:

TEMPERATURE RESISTANCE:

MEDIUM

OPERATING RANGE: 500°F REFERENCE: 208/P.436

TRANSIENT: 600°F REFERENCE: 208/P.436

TEMPERATURE LEVEL FOR
NO DETERIORATION (a)

THRESHOLD FOR NOTED DETERIORATION: (b)

(c)

(d)

REFERENCES: (a) (b) (c) (d)

ARRHENIUS CONSTANT: ln(life) = 11541 (1/T)-21.9

BASIS:

REFERENCE: 4390-00067-CYV/Appendix B

RADIATION RESISTANCE:

RADIATION LEVEL FOR NO DETERIORATION

GAMMA (a) 7.0E06 Rads (Tensile strength)

(b)

THRESHOLD FOR NOTED DETERIORATION

(c) 7.0E07 rads (-50% tensile strength)

(d) 1.0E07 rads (-31.4% compression set)

(e) No visible degradation was noted after 1.54E08 rads exposure.

(f) Demonstrated that silicone rubber O-ring seal performed its function after 1.0E09 rads exposure

(g)

(h)

REFERENCE: (a)178/P.B-173 (b) (c)178/P.B-173 (d)178/P.B-178

(e)4168-00267-BVA/ (f)4390-00067-CYV(g) (h)

DOSE RATE EFFECTS:

REFERENCE:

SYNERGISTIC EFFECTS:

REFERENCE:

MEDIA LIMITATIONS:

REFERENCE:

NOTES:

MATERIAL DATA SHEET

MATERIAL: VITON

GRADE, CLASS: Fluoroelastomer VISCOSITY:

MANUFACTURER(S): DUPONT

SHELF LIFE: REFERENCE:

TEMPERATURE RESISTANCE:

MEDIUM

OPERATING RANGE: 400°F REFERENCE: 15 ←

TRANSIENT: 600°F for 48 Hours REFERENCE: 15 ←

TEMPERATURE LEVEL FOR
NO DETERIORATION (a)

THRESHOLD FOR NOTED DETERIORATION: (b)

(c)

(d)

REFERENCES: (a) (b) (c) (d)

ARRHENIUS CONSTANT: 1.09eV

BASIS: $\ln(\text{life}) = 12639.561\,(1/T) - 19.5298$

REFERENCE: 4022EQ1-00001-BHT/P.9 ←

RADIATION RESISTANCE:

RADIATION LEVEL FOR NO DETERIORATION

GAMMA (a) 1.0E05 Rads to 1.0E06 Rads (Little or no effect)

(b)

THRESHOLD FOR NOTED DETERIORATION

(c) 8.75E06 Rads ($1X10^7$ Roentgens) Max for dynamic applications

(d) 1.0E06 to 1E07 Rads Moderate effects
(50% loss of elongation at break
50% increase in modulus)

(e) 1.0E08 Rads Produces a sever effect (Final elongation at break < 50%)

(f)

(g)

REFERENCE: (a) 171 (b) (c) 15/P.9 (d) 171

(e) 171 (f)

DOSE RATE EFFECTS:

REFERENCE:

SYNERGISTIC EFFECTS:

REFERENCE:

MEDIA LIMITATIONS:

REFERENCE:

NOTES:

REFERENCES

APPENDIX D
SOUTH TEXAS PROJECT
MECHANICAL EQUIPMENT QUALIFICATION
REFERENCE LIST

This Appendix contains a list of selected references from the Equipment Qualification Library; and others which are used in this report.

Ref. No.	Reference Title
6.	Dow Corning - Information about Dimethyl Silicone Compounds, Dow Corning 7, 4, 111 Silicone Compounds.
*8.	Dow Corning - Information about Silicone Elastomers. Silastic 732 RTV Adhesive/Sealant.
10.	EPRI NP 2129, dated November 1981. "Radiation Effects on Organic Materials in Nuclear Plants."
11.	3M Engineering Manual, Kel-F 81 Plastic.
13.	Polymer Handbook, Brandrup and Immergut, Wiley Interscience, N.Y. 2nd Ed., 1975.
*15.	The Engineering Properties of Viton, Fluoroelastomer.
20.	EPRI 1558, dated September 1980. "A Review of Equipment Aging Theory and Technology."
28.	DuPont Tefzel Design Handbook.
40.	Chevron Teknifax - Chevron SRI Grease.
50.	Standard Handbook for Mechanical Engineers, Beumeister and Marks (Seventh Edition).
56.	Nuclear Engineering Handbook, Etherington, First Edition.
57.	Engineering Compendium on Radiation Shielding, Volume II Sponsored by International Atomic Energy Agency. Vienna.
58.	Dow Corning Materials for High Technology Applications. Form No. 10-008A-83.
60.	"Effects of Radiation on Materials and Components" by Kircher and Bowman. Reinhold Publishing Corporation.
*68.	John Crane Packing Recommendations; Technical Data Bulletin, PP-400-1.
*69.	Union Carbide Technical Information Bulletin No. 524-205.
*73.	Dubois Chemicals, A Division of Chemed Corporation. Letter, Dubois Chemicals to Bechtel, dated September 19, 1985, Material Safety Data Sheet. dated 5/14/85, Technical Data/Material Safety Data Sheet, Dubois 910 dated 10/24/84.

* = Document Included

Ref. No. Reference Title

*74. Crane Co.:
Crane, Accessories and Parts, pg. 75;
Telecon Bechtel and Patrick Maney (Crane Co.), dated 9/23/85.
Telecon, Bechtel to Larry Miller (Crane Co., Deming Pumps Division), dated 1/28/86.

*75. Acheson Colloids Company.
Product Data Sheet, DAG 156 (13-108-R282),

*76. Amoco Oil Co.:
Types of Greases;
Product Information Sheet, Amolith Grease #8516
Product Information Sheet, Amolith Greases.
Product Information Sheet, Rykon Premium Greases.

*77. Bel-Ray Co. Inc.:
Technical Bulletin, Molylube No. 80 Grease, Page 1960;
Technical Bulletin, Termalene 80 Grease, Page 1980;
Technical Bulletin, Molylube 80-16 Grease, Page 1965.

*77A Bel-Ray Co. Inc.:
Telecon, Bechtel to P. Hammond (Bel-Ray Co.), dated 5/21/86.

*78. Biddle Instruments:
Letter, Biddle Instruments to Bechtel, dated December 5, 1985,
Composition of Apiezon Products;
Oil, Greases and Waxes for High Vacuum Work - Apiezon, Technical Bulletin 43c.

*79. Exxon Company, USA:
Data Sheet DG-3C, dated 4/26/85, Nebula EP;
Material Safety Data Sheet, Nebula EP0,
Material Safety Data Sheet, Nebula EP1

*80. Lubriplate Division/Fiske Brothers Refining Co.:
Lubriplate Data Sheet
Lubriplate - Lubrication Data Book for all Industries.
Telecons, Bechtel to J. Girard and D. H. Clem (Fiske Bros.), dated 10/4/85 and 1/7/865.

*81. GE Co , Silicone Products Department:
Versilube lubricating greases.

*82. Gulf Oil Corporation:
Gulf Product Data Sheet: Gulfcrown Grease SP15145,
Gulf Product Data Sheet: Gulfgem Grease SP15405-981;
Gulf Product Data Sheet: Gulf Harmony SP15590-882;
Gulf Product Data Sheet: Gulf Harmony SP15589-882,
Gulf Product Data Sheet: Gulf EP Lubricants, HD-series SP15363;
Gulf Product Data Sheet: Gulf Harmony AW SP15588-882;
Gulf Product Data Sheet: Gulfcrown EP Grease SP15155;
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*82B	Gulf Lubrication Charts, with recommendations for alternative lubricant replacements, dated 12/23/85, 3/25/86.
*83.	Halocarbon Products Corp.: Product Data Sheets, Halocarbon Greases.
*84.	Jet-Lube, Inc.: Bulletin No. C-15, Jet-Lube SS-30; Material Safety Data Sheet, dated June 20, 1983; Jet-Lube Anti-Seize Compounds; Sample - Certificate of Compliance for Batch 28092, dated May 2, 1984. Telecons, Bechtel to V. Wilcox (Jet-Lube), dated 1/9/86 and 9/18/85.
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*85A	Telecon, Bechtel to R. Valitsky (Loctite Corp.), dated 3/24/86.
*86	Mobil Oil Co.: Mobil Product Data Sheet, Mobilux 1, 2; Mobil Product Data Sheet, Mobilux EP01,2; Mobil Product Data Sheet, Mobilith AW-1, 2 and 3; Mobil Product Data Sheet Mobilgrease 28, Mobil Product Information, Mobilplex 40 Series Greases; Mobil Industrial Products; NYVAC FR 200 Fluid; Telecons, 1/9/86, 9/18/85, 9/17/85, Bechtel to J. Powell (Mobil Oil).
*86A	Mobil Product Data Sheet, Mobil DTE Oils; Telecon 1/21/86 Bechtel to J Powell (Mobil Oil). "Lubrication Fundamentals," J. George Wills (Mobil Oil Corporation). Copyright 1980.
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*90. Shell Oil Company:
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*92. Texaco, Inc.:
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*93. Valvoline Oil Company, Division of Ashland Oil, Inc.:
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*166.	Letter from Bisco to Bechtel, dated 2/21/86 (E003041).
*167.	Letter from Dow Corning to Bechtel Energy Corporation, dated 3/21/86 (E003042).
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*169.	Telecon, Bechtel (SFO-EQG) to Bechtel (Houston) dated 03/31/86.
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*171.	Radiation resistance of Viton.
172.	14926-4026EQ1-00001-CUL. Wyle report No. 57688-1 "Evaluation of Environmental Qualification and Aging Analysis of Control Valves for use in STP."
*173.	Memorandum from B.P. Shah to B. Dilodare, dated 4/21/86 (IOM 42264).
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*180.	Memo from B D. Shah to B. Dilodare, dated 4/29/86 (IOM #42382).
*181.	Memo from E.A. Goldenberg to B.D. Shah (E003077), dated 4/25/86.
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*188.	Memo #E003087, dated 5/9/86; B. Dilodare (Bechtel-SFO) to B.D. Shah (Bechtel-Houston).
*189.	Memo #E003088, dated 5/8/86; B. Dilodare (Bechtel-SFO) to B.D. Shah (Bechtel-Houston).
*190.	Memo #E003089, dated 5/8/86; B. Dilodare (Bechtel-SFO) to B.D. Shah (Bechtel-Houston).
*191.	Memo #E003097, dated 5/8/86; B. Dilodare (Bechtel-SFO) to B.D. Shah (Bechtel-Houston).
*192.	Telecon: Bechtel-Houston to Bechtel-SFO, 5/20/86.
*193.	Memo #42578, dated 5/9/86; B.D. Shah (Bechtel-Houston) to B. Dilodare (Bechtel-SFO).
*194.	Letter from Dow Corning USA to Bechtel Power Corporation dated May 15, 1986, E003110.
*195.	Memo #E003109, dated 5/21/86; B. Dilodare (Bechtel-SFO) to B. D. Shah (Bechtel-Houston).
*196.	Goodyear Aerospace Corporation "Rubberized Fabric Specification for D-901A."
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*198.	Memo from P. Trudel to B. D. Shah (IOM-041666), dated 3/17/86.
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*200.	Memo from Naz Islam to Mehdi Fard 4/21/86.
*201.	Telephone call from Baldwin Toy to D. Warsing of Limitorque Corporation dated 5/12/86.
*202.	Garlock FCP-3/85-30M 127-AFP Asbestos-Free Valve Stem Packing
*203.	Telecon Bechtel to E. Villalva (Control Components, Inc.) dated 5/27/86.
*204.	Letter, Anchor/Darling Valve Company to Bechtel, #E003116, dated 5/23/86.

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Ref. No.	Reference Title
*246.	Letter, R. O. Bolt to E. A. Goldenberg, dated October 16, 1986, #E003313.
*247.	Garlock Service Condition Reference Table.
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*249.	IOM #44583, R. H. Pence to B. D. Shah, dated September 18, 1986.
*250.	Letter, R. O. Bolt to E. A. Goldenberg, dated September 8, 1986, #E003261.
*251.	Letter, R. O. Bolt to E. A. Goldenberg, dated September 10, 1986, #E003263.
*252.	Letter, R. O. Bolt to E. A. Goldenberg, dated October 20, 1986, #E003314.
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*254.	Letter, R. O. Bolt to E. A. Goldenberg, dated October 15, 1986, #E003309.
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*256.	IOM #46022 R. Witthaver/N. Islam to M. Fard, dated 12/2/1986.
*257.	Telecon (12/2/86): Bechtel (SFO) to Tak Takahashi (Dow Corning).
258.	Dow Corning - "Thermal Aging Program For One Component Silicone Sealants" by S. B. Smith and T. C. Hampton, dated February 1, 1971.
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REFERENCE # 15

SOURCE : MEQ- 1

MECHANICAL
EQUIPMENT
QUALIFICATION

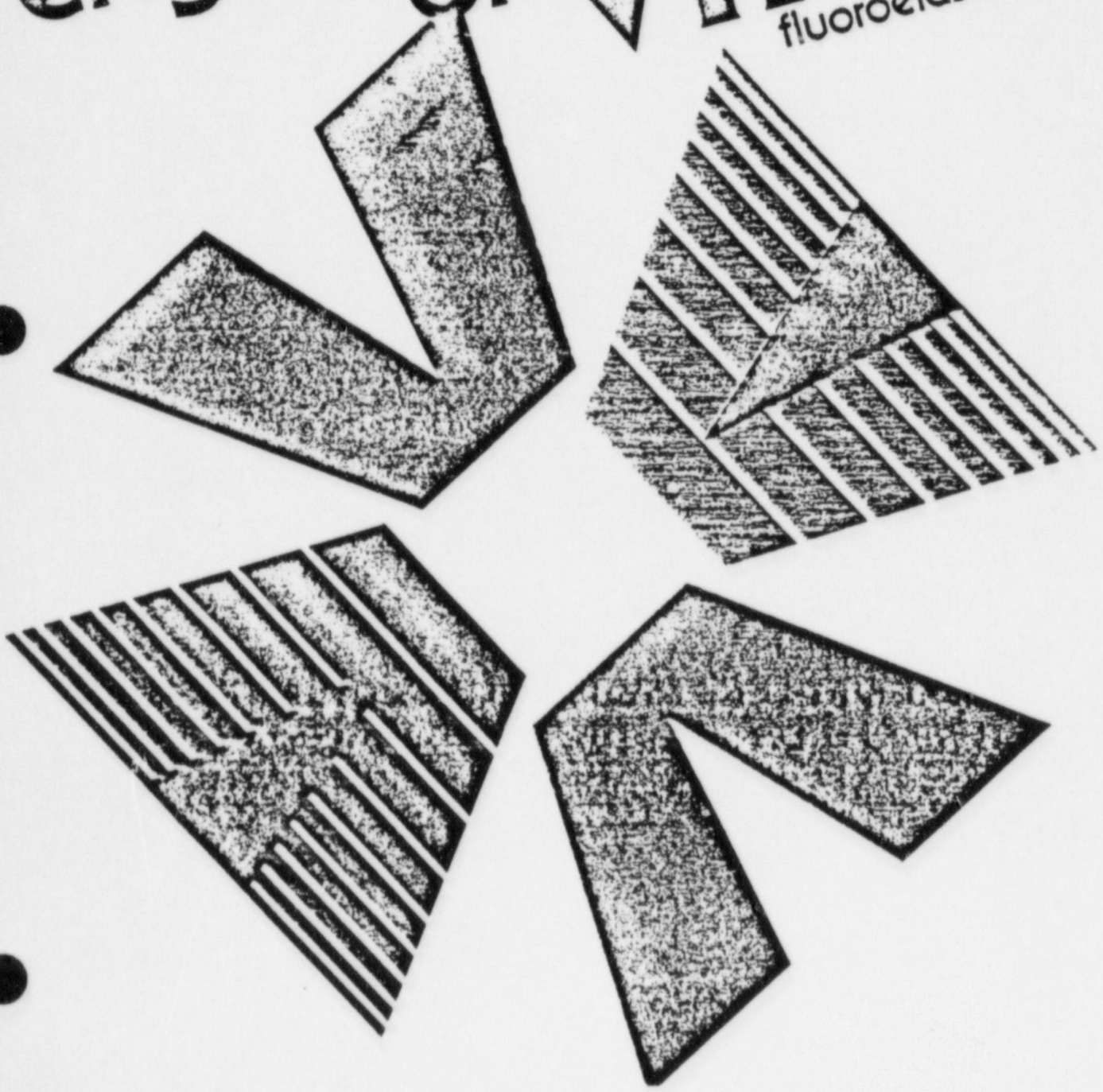
REFERENCE #15
PAGE 1 OF 21

BECHTEL

FERENCE 15

engineering properties of VITON*

fluoroelastomer



product description

VITON* fluoroelastomer, a fluorine-containing hydrocarbon polymer, is a high-performance synthetic rubber with exceptional resistance to oils and chemicals at elevated temperatures. Since its commercialization in 1958, Du Pont has developed a variety of types of VITON possessing specific property improvements, notably in the areas of polymer processing and end product resistance to compression set.

Among the earliest uses of VITON were O-rings for severe service conditions. This continues to be an important application, while sharing its original prominence with a growing number of uses detailed in a later section of this booklet.

VITON is marketed as a raw material to the rubber manufacturing industry by the Elastomer Chemicals Department of Du Pont. No finished products are made from VITON by the Elastomer Chemicals Department.

Our customers offer a variety of solid and cellular products, solvent solutions and coated fabrics, all based on VITON. The compounded product can be molded, extruded, or calendered using standard rubber processing equipment.

table of contents

*Reg. U.S. Pat. & Tm. Off.

properties

VITON* fluoroelastomer is an exceptional rubber. It possesses the traditional rapid recovery from deformation, or resilience, of a true elastomer. It also exhibits mechanical properties of the same order of magnitude as those of conventional synthetic rubbers. However, the resistance properties of VITON are, in many respects, far beyond the range of those of ordinary rubbers. Mechanical and resistance properties of Du Pont VITON will be discussed in that order.

MECHANICAL PROPERTIES

General-purpose formulations of VITON were used for the measurements reported herein, except as specifically noted. The values cited should be taken as representative of what you might expect of a product supplied by a reputable rubber manufacturer. Exact duplication of every figure, however, should not be expected. As is the case with all elastomers, VITON may be compounded to enhance certain properties while compromising, to some degree, certain other properties. But, unless the compounding is drastically modified, mechanical properties of one product made of VITON will closely parallel those of another.

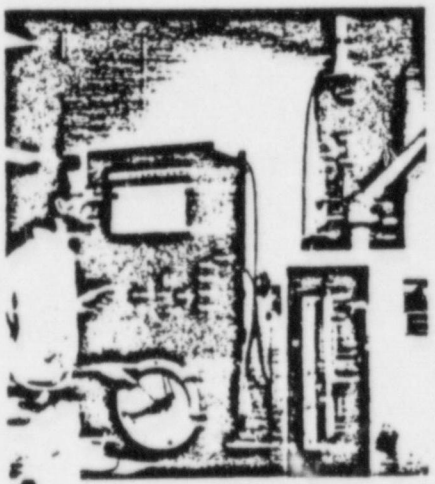
PHYSICAL CONSTANTS

Specific gravities of the raw polymers of VITON range from 1.80 to 1.86. Measurements on typical compounds will closely approximate the following figures:

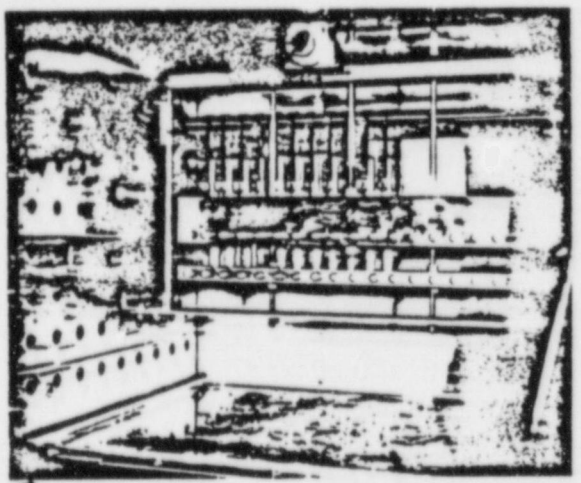
Specific heat—0.395

Coefficient of linear expansion—$AR \times 10^{-4}$/°F. (16×10^{-4}/°C.)

mal Conductivity— 1.58 BTU/in./F./hr. at 100°F. (1.96 kg.cal./cm.²/°C./hr. at 38°C.)

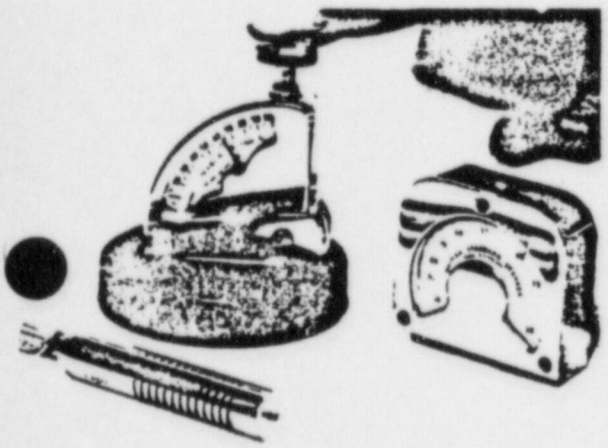


Tensile strength and elongation measurements from −65 to 400°F. (−54 to 204°C.) may be made on VITON in the thermally controlled enclosure of this machine.



The mechanical properties of VITON are evaluated in a variety of equipment, including this dynamic flex tester.

MECHANICAL PROPERTIES



HARDNESS

The durometer A hardness of general-purpose compounds of VITON* fluoroelastomer is approximately 70. Harder and softer formulations (50 to 95) can be furnished and products with great apparent softness may be obtained by the use of cellular VITON.

Depending upon polymer and formulation, hardness may change very little or may decrease 5 to 15 points at temperatures between 250 and 500°F. (121 and 260°C.) Such variations must be taken into consideration in specifying hardness of products used at elevated temperatures.

TENSILE STRENGTH

Compounds of VITON have good tensile strengths, adequate for most applications. A typical value, when tested at 75°F. (24°C.), is 2,000 psi (140.6 kg./cm.^{2}). And, measured at 300°F. (149°C.), the tensile strength of VITON remains in the vicinity of 600 psi (42.2 kg./cm.^{2}).

ELONGATION AT BREAK

Percent elongation at break is a common yardstick for evaluating a rubber's durability in service. The performance of VITON at 75°F. (24°C.) normally ranges from 150 to 300 percent elongation at break. At 300°F. (149°C.) the elongations of typical compounds of VITON range from 75 to 150 percent.

COMPRESSION SET

Figure 1 illustrates the exceptionally good compression set shown by a typical compound of VITON after test compressions for various periods of time at 300°F. and 392°F. (149 and 200°C.). These values become more meaningful when it is realized that most rubbers have a service temperature ceiling less than 250°F. (121°C.)

FABRIC COATING

Coatings of VITON are commonly employed on fabrics to confer necessary heat or fluid resistance to the end product. Adhesion to the fabrics is generally good and, depending upon the heat resistance of the fabric used, temperatures up to 550°F. (288°C.) cause no problems.

Heat stabilities of three representative fluoroelastomer coatings on glass fabric are shown in Figure 2. As can be seen, all three compounds exhibit excellent heat aging properties and are useful for more than 100 hours at 550°F. (288°C.)

Above 500°F. (260°C.) single plies of coated fabrics are more stable than multiple plies. This is because at these high temperatures the decomposition products of VITON cannot escape as readily from multi-ply construction. Their entrapment causes faster deterioration.

Asbestos fabric coated with VITON is used on jet aircraft for firewall sleeves and seals.

*Reg. U.S. Pat. & Tm. Off.

Figure 1
Long-Term Compression Set of VITON

Time, hr.	At R.T.	At 300°F. (149°C.)	At 392°F. (200°C.)
	Compression set, %*		
1,000	—	12	50
2,000	—	16	65
4,000	21	22	79
8,000	21	32	98

*ASTM D395, Method B. (O-rings)

RESILIENCE

The dynamic properties of VITON* fluoroelastomer make it suitable for use as a vibration isolator at high temperatures and as a vibration damper (energy absorber) at room temperature. In the latter case, however, it would normally be employed only in very corrosive environments.

ADHESION TO METALS

VITON can be adhered to a variety of metals, using special adhesive formulations also based on VITON. Assemblies do not fail at the bond. Bond strength exceeds the tear strength of cured VITON, both at 75°F. (24°C.) and at temperatures as high as 400°F. (204°C.). The adhesive bonds also endure 500°F. (260°C.) heat aging. Figure 3 lists representative peel adhesion values between VITON and some common metals.

SPONGE PROPERTIES

Cellular VITON, in densities from 10 to 95 lb./ft.^{3}, (0.16 to 1.52 g./cm.^{3}), offers the advantages of extreme softness and compressibility while retaining to a high degree the exceptional heat and fluid resistance of solid fluoroelastomer products. Both open and closed cell materials can be produced.

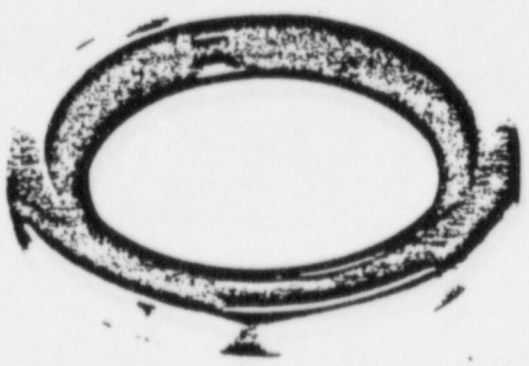
Figure 2
Heat Stability of Glass Fabric Coated with VITON

	Compound A		Compound B		Compound C	
	1 ply	2 ply	1 ply	2 ply	1 ply	2 ply
Original grab tensile strength, lb./linear in. (kg./cm.)	91 (16.2)	194 (34.6)	80 (14.3)	190 (33.9)	109 (19.5)	185 (33.0)
After 50 hr. oven aging at 550°F. (288°C.)	93 (16.6)	123 (22.0)	57 (10.2)	121 (21.6)	94 (16.8)	128 (22.9)
After 100 hr. oven aging at 550°F. (288°C.)	78 (13.9)	98 (17.5)	54 (9.6)	102 (18.2)	74 (13.2)	107 (19.1)
% Weight Loss						
After 50 hr. oven aging at 550°F. (288°C.)	6.7	7.4	8.0	8.7	7.8	8.4
After 100 hr. oven aging at 550°F. (288°C.)	12.2	15.2	13.9	19.8	13.8	18.2

Figure 3
Adhesion of VITON to Metals*

Metal	Original Measured at 75°F. (24°C.)	Aged 64 hr. at 500°F. (260°C.) Measured at 75°F. (24°C.)	Measured at 400°F. (204°C.)
Aluminum	160 (28.6)	20 (3.6)	6 (10.7)
Brass	160 (28.6)	20 (3.6)	6 (10.7)
Steel	160 (28.6)	20 (3.6)	6 (10.7)

*180° peel adhesion in lb./linear in. (kg./cm.). All failures were by stock tearing.



*Reg. U.S. Pat. & Tm. Off.

RESISTANCE PROPERTIES

Again we point out the influence of compounding upon specific properties; like acid resistance, electrical characteristics, water absorption, etc. General-purpose formulations of VITON* fluoroelastomer will be referred to throughout unless otherwise indicated.

It is important to note that if you require a high degree of resistance to a specific exposure you should stress this fact to your rubber supplier. He can furnish you with a product specially compounded to suit your purpose. For instance, volume swell of VITON in hot water can be reduced by two-thirds without significant sacrifice in overall performance. Similar improvement of other resistance properties can be achieved through special compounding.

HIGH TEMPERATURE

VITON withstands high temperature and simultaneously retains its good mechanical properties better than any other elastomer. Oil and chemical resistance also are relatively unaffected by elevated temperatures. Compounds of VITON remain usefully elastic indefinitely when exposed to laboratory air oven aging up to 400°F. (204°C.). Continuous service limits are generally considered to be:

>3,000 hours at 450°F. (232°C.)
1,000 hours at 500°F. (260°C.)
240 hours at 550°F. (288°C.)
48 hours at 600°F. (315°C.)

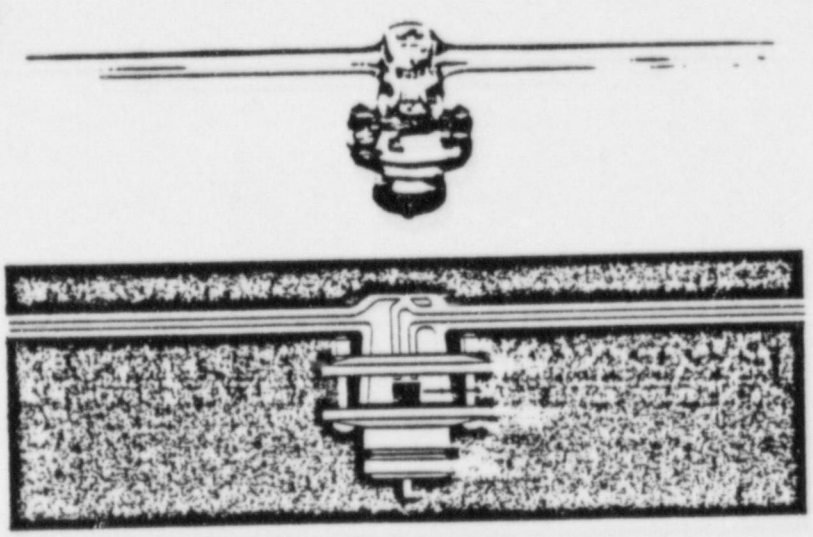
LOW TEMPERATURE

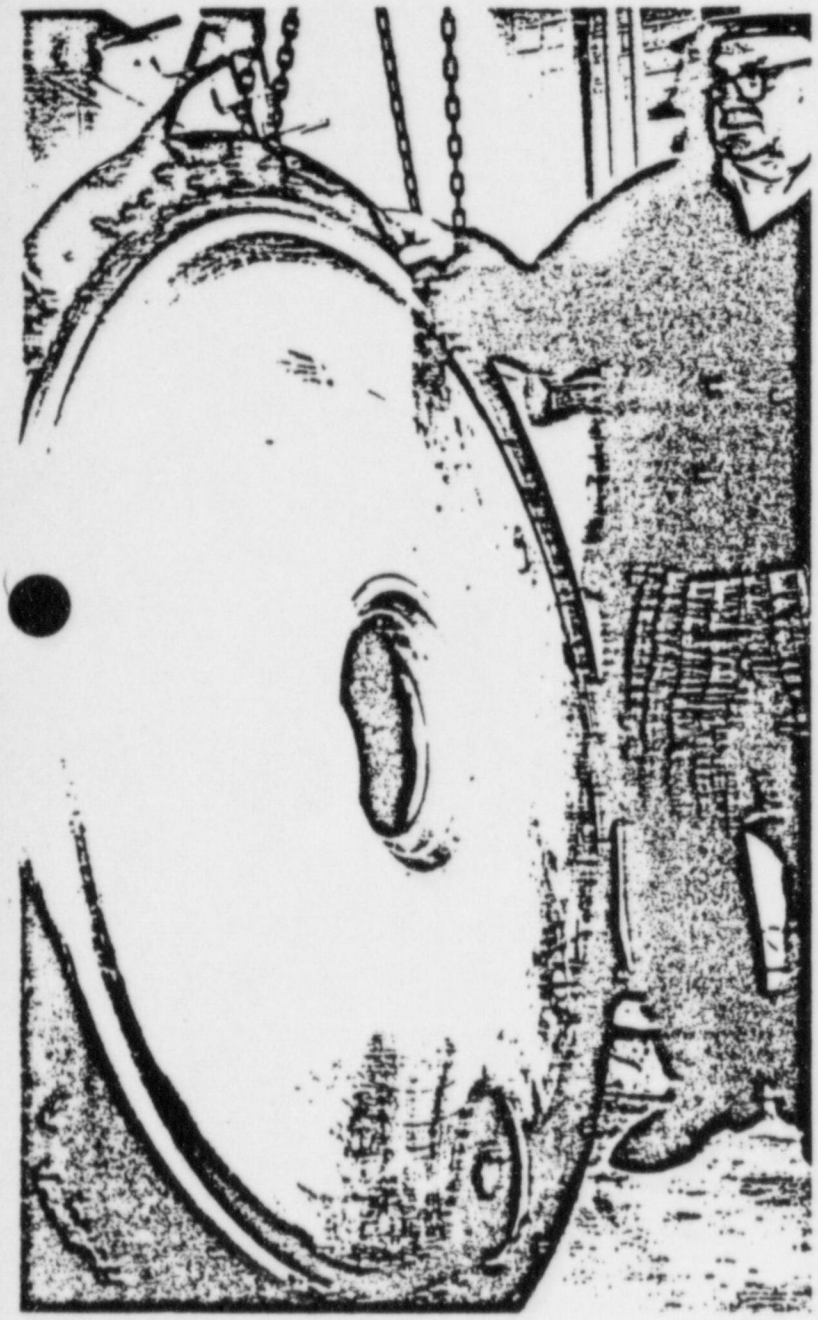
Especially in aircraft and space equipment, both low and high temperature conditions must be satisfied. VITON is generally serviceable in dynamic applications down to −10°F. (−23°C.).

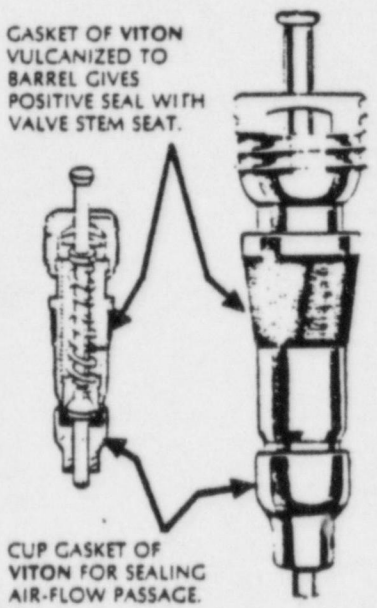
Thickness of the sample has a marked effect upon tests of flexibility at low temperature; the thinner cross sections, of course, exhibiting less stiffness than thicker ones at every temperature. The brittle point of VITON, at a thickness of 0.075 in. (1.9 mm.), is in the neighborhood of −50°F. (−45°C.). Depending upon thickness and hardness, this value may range from −25 to −75°F. (−32 to −59°C.). Under certain conditions, some of these fluoroelastomer products perform satisfactorily in dynamic applications at temperatures approaching their brittle points.

Although VITON has limitations at very low temperatures when dynamic service is required, static applications are readily handled. As a matter of fact, general-purpose O-rings made of VITON have proven satisfactory as static seals under cryogenic conditions approaching absolute zero.

Greaseless stopcock for high-vacuum (1×10^{-4} mm. Hg) service up to 450°F. (232°C.) is closed by a resilient diaphragm of outgassing- and radiation-resistant VITON.







Valve inside jet aircraft wheels uses gaskets of VITON* fluoroelastomer. Specification calls for operation from −65 to 500°F. (−54 to 260°C.) plus pressures over 300 psi (21.1 kg./cm.²).

The flange seal of VITON on this vacuum drier cover was in place for 12 years. Estimated temperatures within the jacketed stainless steel vessel ran 460–480°F. (238–249°C.) and the contents were acidic organics. Seal replacement was made only when the drier had to be mechanically overhauled. At no time had the seal shown any evidence of leaking.

*Reg. U.S. Pat. & Tm. Off.

RESISTANCE PROPERTIES

FLUID RESISTANCE

VITON* fluoroelastomer has the best proven fluid resistance characteristics of any commercial rubber available to date. It has excellent resistance to oils, fuels, lubricants, most mineral acids, and resists many aliphatic and aromatic hydrocarbons (carbon tetrachloride, benzene, toluene, xylene) that act as solvents for other rubbers.

On the other hand, VITON is not recommended for service in low molecular weight esters and ethers, ketones, certain amines, hot anhydrous hydrofluoric or chlorosulfonic acids, and a few proprietary fluids such as Skydrol 500A. The solubility of VITON in low molecular weight ketones is, of course, useful in producing solution coatings of VITON.

Tabulated on pages 18-19 are evaluations of VITON versus a representative list of nearly 200 fluids.

GAS PERMEABILITY

VITON is relatively impermeable to air and gases, ranking about midway between the best and the poorest elastomers in this respect. These comparative measurements were made using standard-sized specimens (1 sq. cm. by 1 cm. thick) of typical compounds, each exposed to a pressure differential of one atmosphere at 176°F. (80°C.)

The permeability of VITON can be modified considerably by the way it is compounded. But, in all cases, permeability increases rapidly with increasing temperature. Additional data on the permeability of VITON are tabulated in Figure 4.

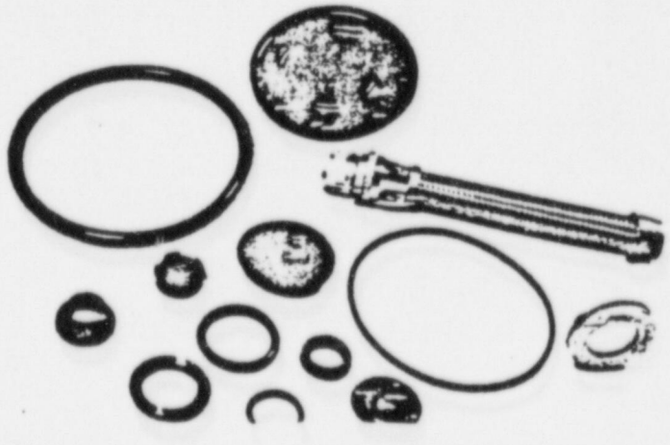
High-temperature fluid resistance tests in the laboratory confirm that products of VITON, such as those shown at right, will successfully perform in the field where other rubbers fail completely.

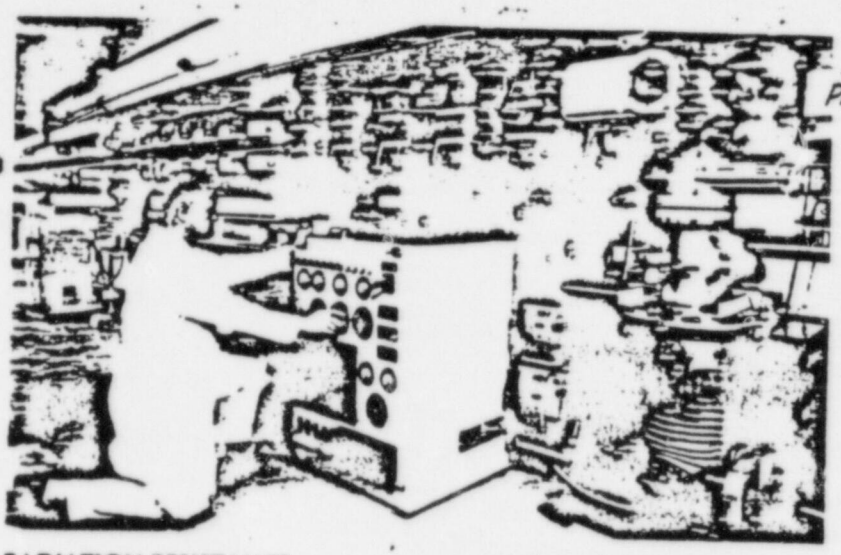
Figure 4

Permeability* of Compounded VITON

	75°F. (24°C.)	86°F. (30°C.)	250°F. (121°C.)	400°F. (204°C.)
Air	0.0099×10^{-7}	—	—	—
Carbon dioxide	—	0.59×10^{-7}	—	—
Helium	0.892×10^{-7}	—	17.4×10^{-7}	67.0×10^{-7}
Nitrogen	0.0054×10^{-7}	—	—	—
Oxygen	—	0.11×10^{-7}	—	—

*c.c./cm.²/cm./sec./atm.





Vacuum chamber of giant proton accelerator, one-half mile (800 m.) in circumference, was gasketed with radiation-resistant, non-volatilizing VITON to improve the vacuum to 1×10^{-7} in. Hg.

FLAMMABILITY

VITON* fluoroelastomer, like Neoprene and HYPALON* synthetic rubber, is a halogen-containing polymer and thus is more resistant to burning than are exclusively hydrocarbon rubbers.

In laboratory tests, products made of normally compounded VITON will burn if directly exposed to flame but will go out when the flame is removed. Natural rubber and many synthetics will, under the same conditions, continue to burn. However, despite its advantage over other materials in such laboratory tests, VITON will burn if involved in an actual fire situation.

Special compounding can enhance the flame resistance of VITON. One formulation, specifically developed for the Space Program, will not ignite under conditions of the NASA test, which specify 100 percent oxygen at 6.2 psi (absolute).

FOOD AND DRUG CONTACT

The U.S. Food and Drug Administration has amended its regulations to provide for the use of vulcanizates of VITON in the formulation of rubber articles intended for repeated food contact use.

More details are available in the Federal Register, Vol. 33, No. 5, Tuesday, January 9, 1968. Part 121—Food Additives. Subpart F—Food Additives Resulting From Contact With Containers or Equipment and Food Additives Otherwise Affecting Food—Rubber Articles Intended for Repeated Use.

ABRASION RESISTANCE

End products made from VITON are tough and long wearing. In the ...ber abrasion test a loss per ...volution of 0.1-0.2 milligrams, ...ith a H-22 wheel and 1.000-gram ...oad was measured on a typical compound of VITON.

RADIATION RESISTANCE

Exposure of VITON to gamma radiation from a cobalt-60 isotope source brings about an increase in hardness and stiffness. This seems to be as a result of an increased state of cure induced by the radiation. For dynamic applications, VITON should not be exposed to radiation exceeding 1×10^7 roentgens. For static applications, higher dosages are permissable. VITON gives no evidence of radiation-induced stress cracking.

VITON ranks about midway among commonly available elastomers with respect to radiation resistance alone. However, since high temperature is frequently involved simultaneously with exposure to radiation, the practical effectiveness of VITON correspondingly increases. In many cases, the temperatures will rule out most other elastomers and plastics.

ELECTRICAL PROPERTIES

The electrical properties of VITON suggest its use as a wire insulation for low voltage, low frequency applications requiring unusual heat and fluid resistance. It normally has a D.C. resistivity on the order of 2×10^{13} ohm-cm., a dielectric constant around 10, dissipation factor of about 0.05 and a dielectric strength of 500 volts per mil (2,000 volts per mm.).

ENVIRONMENTAL RESISTANCE

VITON has excellent resistance to atmospheric oxidation, sun and weather. Samples weathered in direct sunlight showed little or no change in properties or appearance after 13 years' exposure in Florida. The same is true for samples exposed to various tropical conditions in Panama for ten years.

Articles produced with VITON are unaffected by ozone concentrations as high as 100 ppm. No cracking occurred in a bent loop test after one year's exposure to 100 ppm of ozone in air at 100°F. (38°C.).

The biological resistance of VITON also is excellent. A typical compound tested against specification MIL-E-5272C showed no fungus growth after 30 days. This spec covers four common groups of fungi.

Under extreme vacuum conditions VITON exhibits a weight loss of only 2-3 percent, indicating that it is virtually completely immune to outgassing. Products of VITON are commonly baked at 400-500°F (204-260°C.) for 16-24 hr. in order to post-cure them. This procedure removes virtually all volatiles before the item goes into service.

Figure 5
Electrical Properties of VITON at Various Temperatures (Tested in air)

	75°F. 24°C.	300°F. 149°C.	390°F. 199°C.
Dissipation Factor, (1,000 Hz.)	0.034	0.273*	0.39 to 1.19*
Dielectric Constant, (1,000 Hz.)	10.5	7.1	9.1

V applications

AUTOMOTIVE

Many opportunities exist for the incorporation of VITON® fluoroelastomer in parts for the engine and drive train of modern passenger vehicles and trucks. Cost is a major factor in this industry and any use of a high-priced elastomer like VITON is an exceptional testimonial to its premium performance. However, the long-term value provided by VITON is being increasingly recognized as justifying its use in place of cheaper materials as performance insurance for certain automotive parts. This is true not only for extreme exposure conditions but, in some cases, also where only moderate conditions are normally encountered.

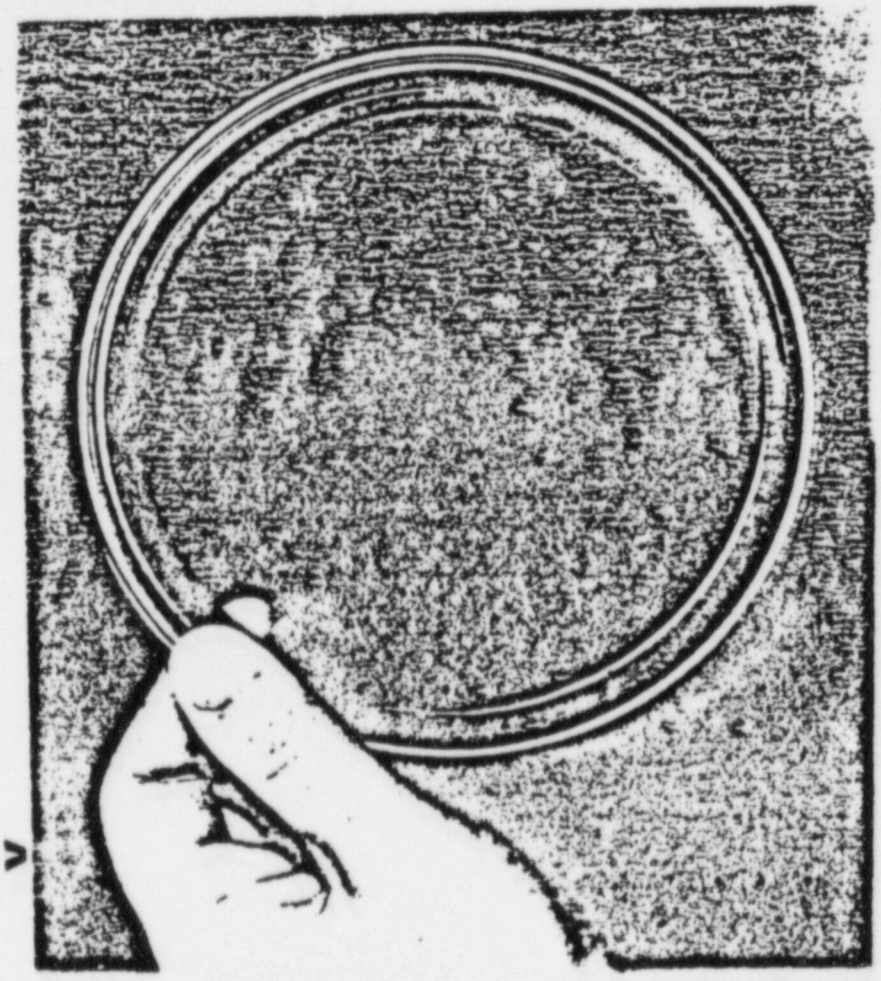
In carburetors, needle valves tipped with VITON provide a resilient, fuel-resistant, abrasion-resistant seating material that is the key to a non-flooding carburetion system. A component of VITON on truck carburetors is the accelerator pump cup which must remain dimensionally stable within close tolerances in order to function properly.

Valve stem oil seals made of VITON have been used for a number of years on one line of heavy-duty truck engines designed for 100,000 miles (160,930 km.) of maintenance-free operation. And many have run over 150,000 miles (241,395 km.) without incident—a severe test of heat and oil resistance.

Since 1962, VITON has been the standard seal material on diesel engine brake solenoids. These devices have been installed in more than 50,000 vehicles ranging from city buses to logging trucks. The O-ring seals of VITON were purchased against MIL-R-25897 specification and hold against hot lube oil at up to 60-70 psig (4.2-4.9 kg./cm².) in the truck engine.

Off-the-road equipment also uses VITON. A major manufacturer has standardized on VITON for rear crankshaft lip seals in its heavy-duty diesel engines used on certain of its earthmoving machines. Some of these engines have run 8,000 hr. between overhauls as a result. Hydraulic fittings in automotive service are reliably sealed against vibration-induced leakage by sleeves of VITON which absorb angular displacement and withstand hot oils. And automatic transmission front pump seals of VITON have proven their worth after years of successful service.

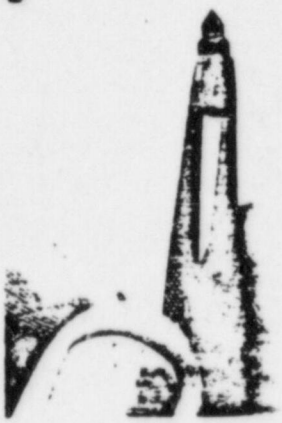
Other automotive uses for VITON include an axle pinion shaft seal, diesel cylinder liner seals, solenoid plunger tips, seals for automatic transmissions in buses, vacuum tubing and diaphragm for a spark advance mechanism.

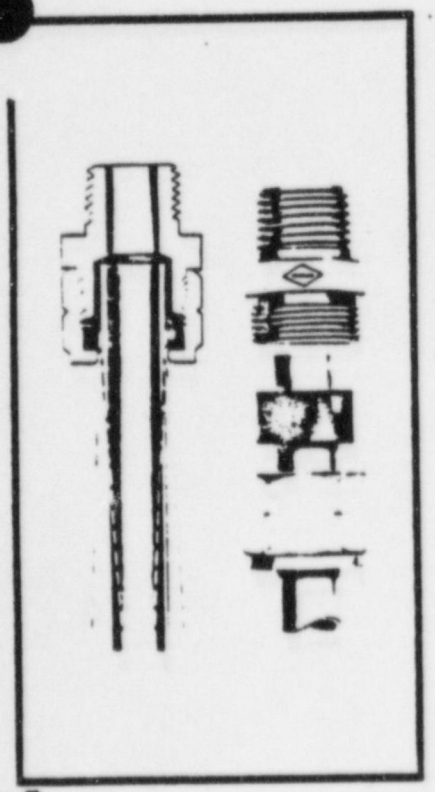


Rear crankshaft seal of VITON on earthmovers' diesels has reduced maintenance and prolonged engine life.

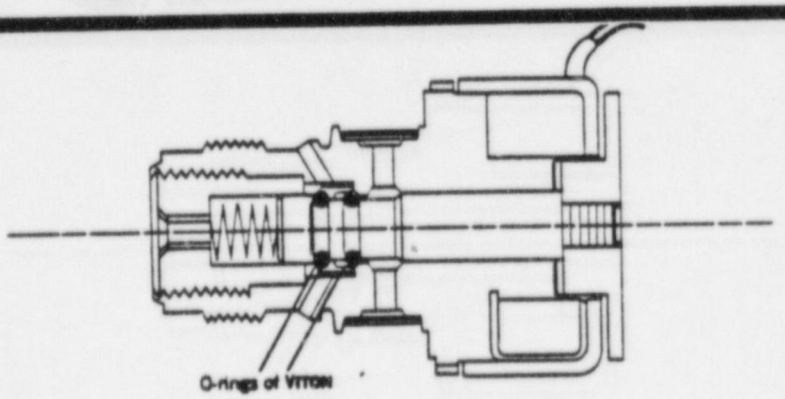
Engine brakes sealed with VITON* fluoroelastomer are giving truckers lower maintenance costs per mile.

VITON on tip of carburetor needle valve prevents flooding, does not swell in aromatic fuels.





ON keeps hydraulic fittings ck-tight.



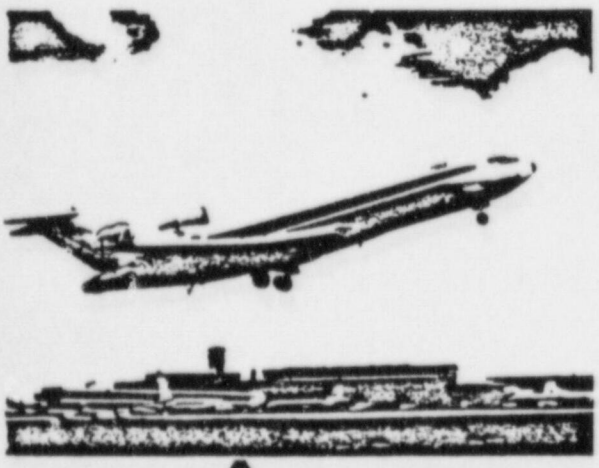
Solenoids controlling hydraulic operation of diesel engine brakes have seals of hot oil-resistant VITON.

*Reg. U.S. Pat. & Tm. Off.

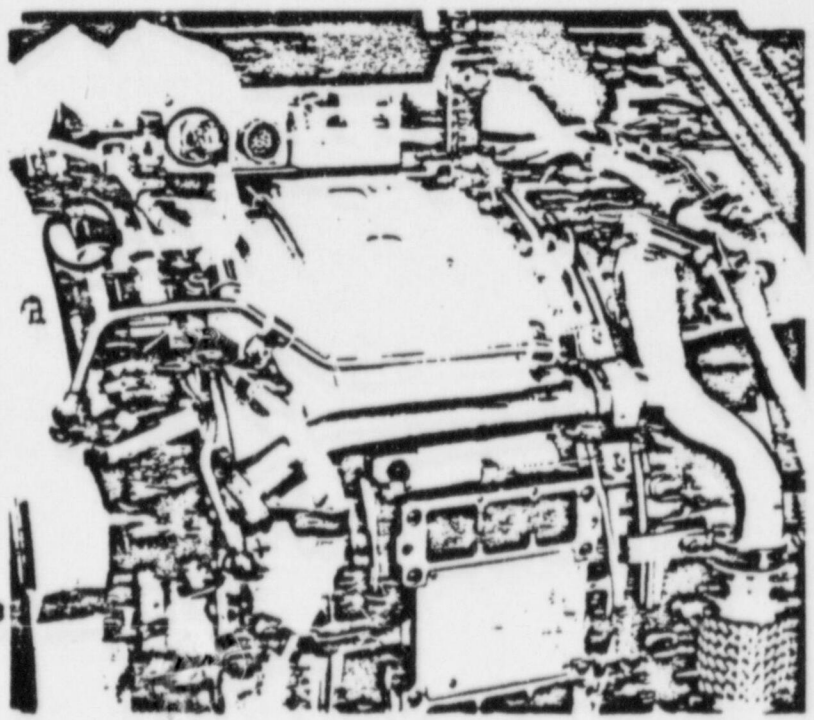
applications

AIR AND SPACE

Piston-type as well as jet engines employ VITON® fluoroelastomer for resistance to heat, lubricants and fuels. Seals of VITON are now standard on major airlines.



Commercial jetliners use VITON in many critical applications where exceptional heat and oil resistance are necessary requirements.

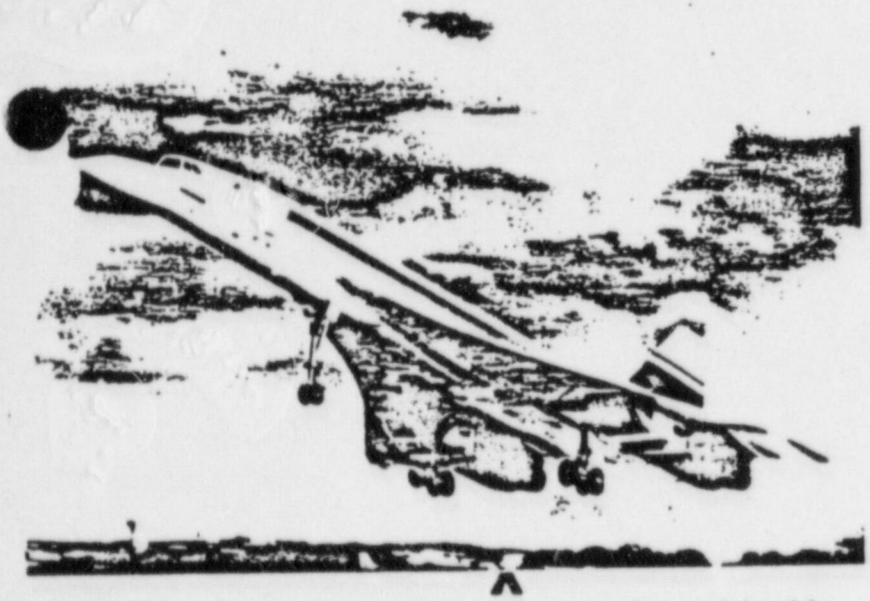


Connector seals on jet engine wiring harnesses are VITON for heat, oil, weather and vibration resistance.

Reliability of materials under extreme exposure conditions is a prime requisite in this field. The high and low temperature properties of VITON* fluoroelastomer have been well demonstrated in a number of aircraft and missile components; manifold gaskets, coated fabrics, firewall seals, heat-shrinkable tubing and fittings for wire and cable, mastic adhesive sealants, protective coatings and numerous O-ring seals. An additional characteristic of VITON pertinent to space components is its ability to seal against "hard" vacuum, down to a range of 10^{-9} mm. Hg by actual test.

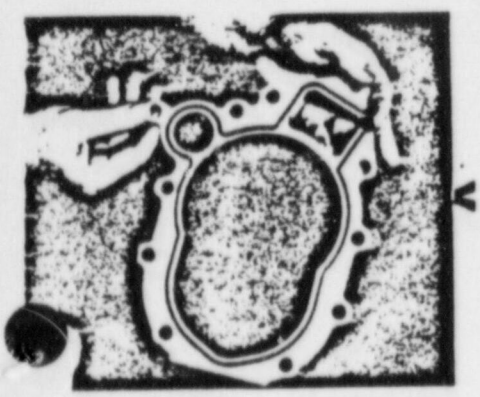
Aircraft designers have reported O-rings of VITON have a usable thermal range of −65 to +600°F. (−54 to +315°C.); and at 680 to 730°F. (360 to 388°C.) tests have been successful but service life is reduced to about 30-40 hours. They further report that VITON has excellent abrasion resistance and resistance to thermal cycling, a common condition encountered in rapid ascent to, and descent from, the stratosphere or higher. In several tests, VITON sealed just as well at room temperature, and also at reduced temperatures, after 40 thermal cycles as it did when new. Other elastomers, after two or three thermal cycles, would no longer maintain their seals at room temperature. One study on the service life of O-rings, run by an aircraft manufacturer, involved dynamic tests at elevated temperatures. O-rings of VITON, properly designed and installed according to their recommendations, proved capable of successfully completing 50,000-cycle compression tests at 500°F. (260°C.)

Among other applications of VITON in aviation are its uses as an abrasion-resistant solution coating over braid-sheathed ignition cable; heat-resistant connector seals on jet engine wiring harnesses; flexible, impregnated fiber glass sheathing for electric wire; coated fabric covers for jet engine exhausts between flights; and syphon hose for hot engine lubricants.



VITON is extensively used aboard the supersonic CONCORDE in structural sealants and gasketing, fire-resistant coated fabric, cable jacketing, protective coatings and various seals.

Jet engine exhaust covers are made of glass fabric coated with VITON to stand 500-700°F. (260-371°C.)



Molded-in-place, reusable seals of VITON are designed for "hard-vacuum" space applications, below 1 x 10^{-7} mm. Hg, and permit use of intricate configurations.

*Reg. U.S. Pat. & Tm. Off.

applications

CHEMICAL INDUSTRY

A "universal" material of construction is the ideal sought by harried production and maintenance engineers in this rough-on-equipment industry. The high costs involved in dismantling and replacing failed components, to say nothing of the production losses, far outweigh any materials cost factor. Standardization on VITON® fluoroelastomer is becoming more common as its economic justification in longer production runs between maintenance shutdowns is being more widely demonstrated. In two documented instances, chemical piping and equipment seals have remained in uninterrupted service for over 10 years.

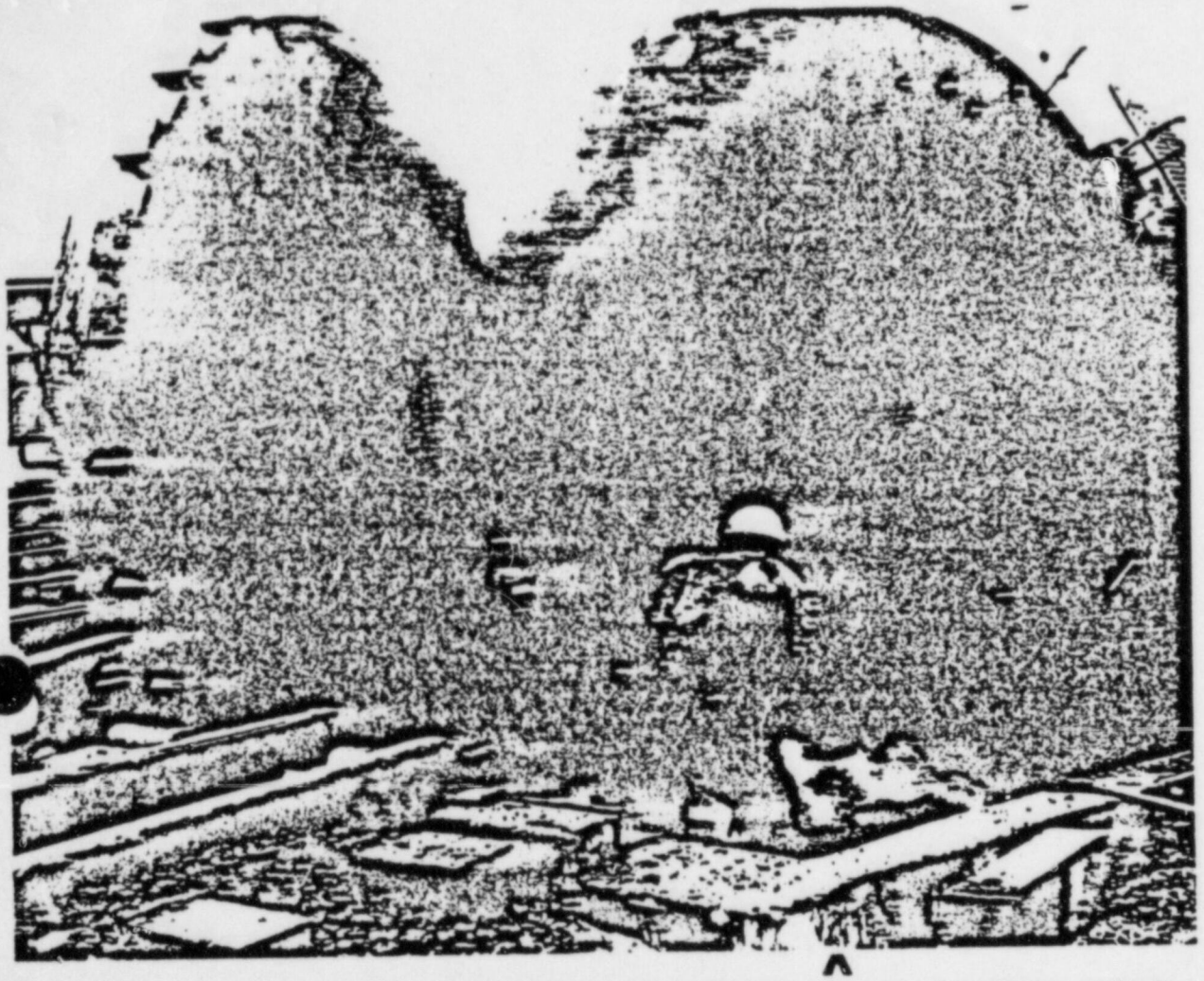
VITON is very close to being a universal seal for chemical process equipment. One example is a pumping station handling more than 80 different solvents, oils and chemicals. Seals of VITON used in the piping's swivel joints and telescoping joints were inspected after two years' service and found to be as good as the day they were installed.

Another example is a door gasket for a wood impregnation autoclave. Temperatures to 245°F. (118°C.), steam pressures of 150 psig (10.5 kg./cm.^{2}), and exposure to cresol oils and other phenolics are involved. VITON overcame the permanent set deficiency of the original woven asbestos gasketing and gave much longer service than previously tried synthetic rubber seals.

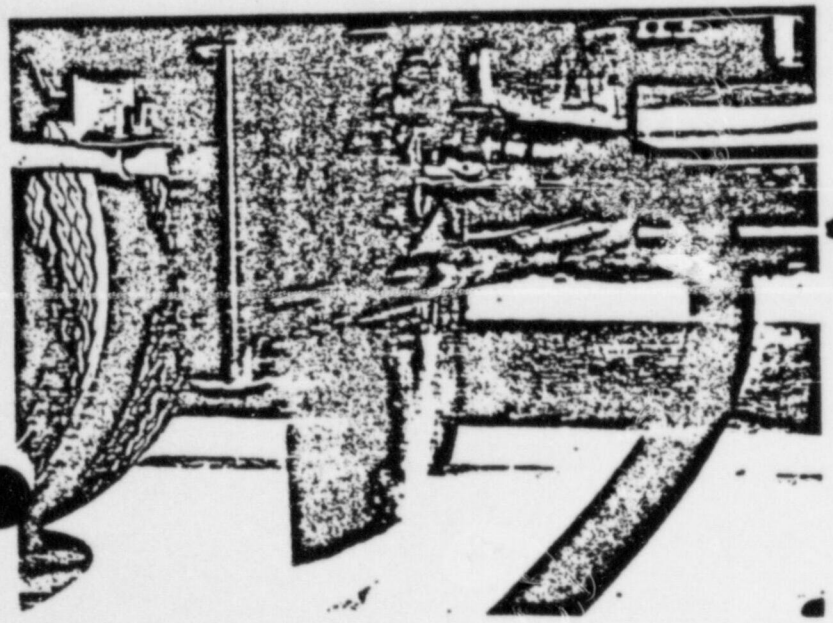
A third example is the rotameter manufactured by a leading supplier of measurement and control equipment. All of its rotameters intended for metering chemicals are furnished with O-ring seals of VITON. This adoption of a "universal" seal has simplified the production and markedly reduced the number of customer service calls on the instrument.

But VITON serves the chemical industry in more ways than as seals alone. Fluoroelastomer lined valves eliminate heat and corrosion worries in many a plant. Transfer hose for solvents and reactive petrochemicals is in daily use for both processing and distribution facilities. Included are installations on ocean tankers as well as highway trailers. Proportioning pumps handling highly reactive chemicals are equipped with diaphragms of VITON. Processing rolls for hot or corrosive service are covered with VITON. And aerosol-propelled solvent solutions of VITON are sprayed on as multi-purpose maintenance coatings throughout the chemical industry.

Packing of pipeline swivel joint is heavily encrusted with deposits after years of handling a variety of solvents, yet it remains as leak-free as when first installed because it's made of VITON.



Door of wood impregnation autoclave is sealed against hot phenolic preservatives by an O-ring of VITON* fluoroelastomer. The improved steam/vacuum sealing system replaced woven asbestos gaskets.



Severe chemical attack destroyed tank truck transfer hose after only one delivery. Then a hose lined with VITON was tried. Now the hose lasts over a year in routine tanker use.

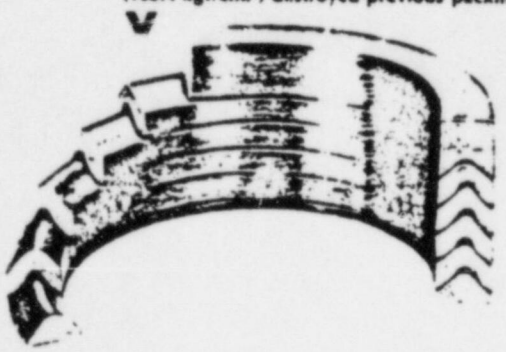
V applications

MISCELLANEOUS INDUSTRIAL USES

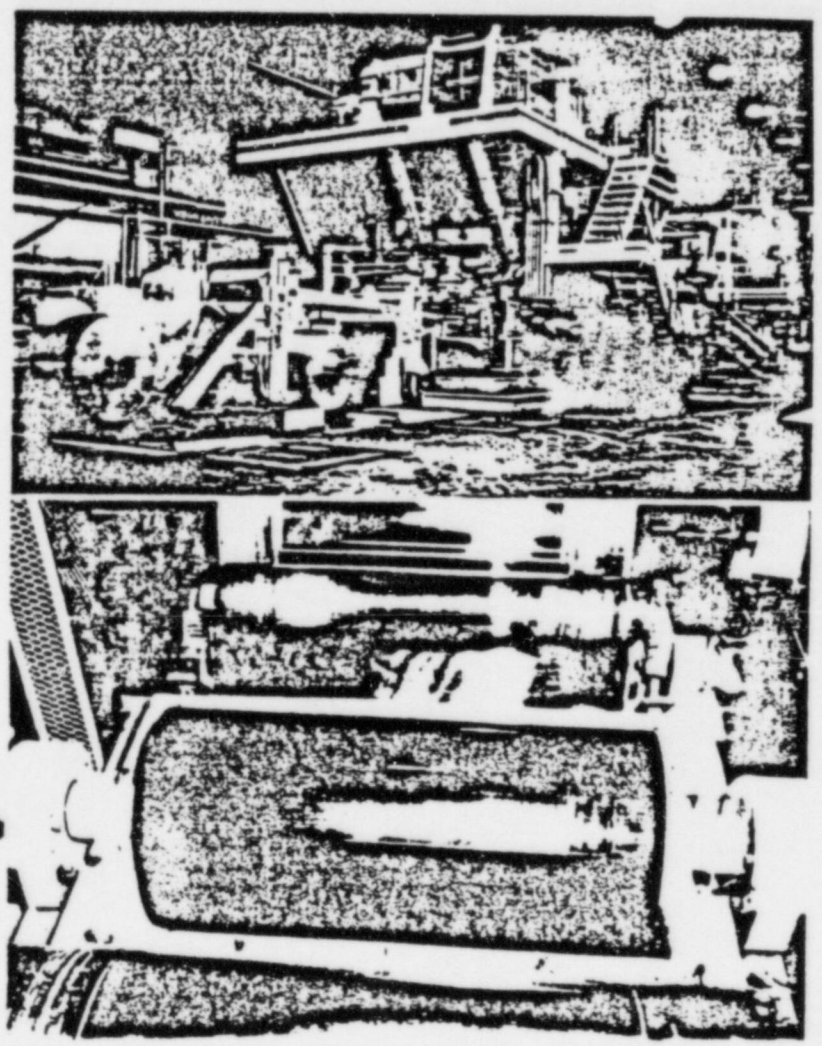
Cutting across all industry lines are a wealth of additional applications where the good mechanical properties of VITON* fluoroelastomer have permitted it to replace conventional elastomers. To cite a few: stable-dimensioned O-ring seals in the meters of automatic gasoline blending pumps, high-vacuum seals for a proton accelerator, a heat- and corrosion-resistant expansion joint for a utility company's stack gas exhaust ducts, tubing and seals for a variety of premium-grade industrial instruments, conveyor tires for hot plate glass, packing rings for hydraulic activators on steel mill ladles, jacketing for steel mill signal cable, deflector rolls on high-speed tinplating lines, precision-molded balls for check valves in oil or chemical service, and an assortment of O-ring seals for test equipment in an automotive manufacturer's experimental lab.

The lattermost example well illustrates the general principle that we have been stressing in this booklet. Previously, various test machines had to be dismantled every few days to repair leaks. Use of VITON permits the units to run continuously for three months without attention to the seals. Seals now are customarily replaced only during periodic maintenance overhauls. Exposure is to a variety of hydraulic fluids at temperatures up to 325°F. (163°C.) and pressures, in some cases rapidly alternating, up to 2,000 psi (140.6 kg./cm.²).

According to the lab's mechanical design engineer, their previous seals "baked so hard they snapped like pretzels" when removed after a short time because of leakage. The switch to VITON eliminated a real maintenance headache and, he feels, has come very close to providing the long-sought "universal seal."



Molded packing rings, made of VITON reinforced with asbestos cloth, seal hydraulic actuators of steel mill ladles. Reactive, nonflammable hydraulic fluids at 550°F. (288°C.) and 1,500 psig (105.4 kg./cm.²) destroyed previous packings.



On a continuous tinplating line a deflector roll covered with VITON has outlasted the previous roll by more than 12 to 1.

*Reg. U.S. Pat. & Tm. Off.

applicable specifications

MIL-R-83248

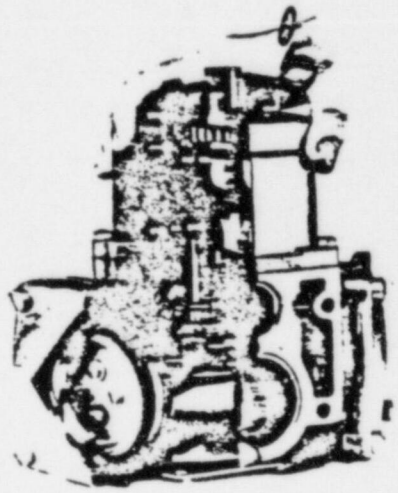
	Spec	VITON
Original		
Tensile Strength, psi	1,600	1,735
, kg./cm.²	112.5	122.0
Elongation, %	125	190
Hardness, Durometer A points	75 ±5	79
T_{10} °F., max.	+5	−4
T_{10} °C., max.	−15	−20
Compression Set—ASTM D395, Method B 70 hr. at 75°F. (24°C.), %	15	12
Aged 70 hr. at 75°F. (24°C.) in Reference Fuel B		
Tensile Strength, % change	−20	−15
Elongation, % change	−20	−10
Hardness, points change	±5	−2
Volume, % change	0 to +10	+1.6
Aged 70 hr. at 347°F. (175°C.) in Stauffer Blend 7700		
Tensile Strength, % change	−25	−22
Elongation, % change	−20	−5
Hardness, points change	0 to −15	−7
Volume, % change	0 to +20	+16.4
Compression Set—ASTM D395, Method B		
Standard Measurement, %	10	0
Measurement After 18-hr. Cooling, %	15	7
Aged 70 hr. at 528°F. (275°C.) in Air		
Tensile Strength, % change	−35	−20
Elongation, % change	−15	+42
Hardness, points change	−5 to +10	+1
Weight, % change	−10	−5.06
Compression Set—ASTM D395, Method B		
22 hr. at 392°F. (200°C.), %	15	8
Compression Set—ASTM D395, Method B		
Aged 166 hr. at 347°F. (175°C.)		
Standard Measurement, %	20	15
Measurement After 18-hr. Cooling, %	35	24

AMS-7278D

	Spec	VITON
Original		
Tensile Strength, psi	1,200	1,735
, kg./cm.²	84.4	122.0
Elongation, %	125	190
100% Modulus, psi	350	880
, kg./cm.²	24.6	61.9
Hardness, Durometer A points	75 ±5	79
T_{10} °F., max.	+5	−4
T_{10} °C., max.	−15	−20
Aged 70 hr. at 75°F. (24°C.) in Reference Fuel B		
Tensile Strength, % change	−15	−15
Elongation, % change	−15	−10
Hardness, points change	−5 to +5	−2
Volume, % change	0 to +10	+1.6
Aged 70 hr. at 392°F. (200°C.) in Anderol L-774		
Tensile Strength, % change	−40	−13
Elongation, % change	−20	+11
Hardness, points change	−15 to +5	−7
Volume, % change	0 to +20	+11.3
Aged 70 hr. at 482°F. (250°C.) in Air		
Tensile Strength, % change	−30	−2
Elongation, % change	−40	−10
Hardness, points change	0 to +15	+1
Weight, % change	−8.0	−0.94
Compression Set—ASTM D395, Method B		
70 hr. at 392°F. (200°C.),%	50	13

AMS-7280

	Spec	VITON
Original		
Tensile Strength, psi	1,600	1,735
, kg./cm.²	112.5	122.0
Elongation, %	125	190
Hardness, Durometer A points	75 ±5	79
T_{10} °F., max.	+5	−4
T_{10} °C., max.	−15	−20
Aged 70 hr. at 75°F. (24°C.) in Reference Fuel B		
Tensile Strength, % change	−15	−15
Elongation, % change	−15	−10
Hardness, points change	−5 to +5	−2
Volume, % change	0 to +10	+1.6
Aged 70 hr. at 392°F. (200°C.) in Stauffer Blend 7700		
Tensile Strength, % change	−40	−26
Elongation, % change	−20	−16
Hardness, points change	−15 to +5	−9
Volume, % change	0 to +25	+19.5
Aged 70 hr. at 482°F. (250°C.) in Air		
Tensile Strength,% change	−20	−2
Elongation, % change	−20	−10
Hardness, points change	0 to +10	+1
Weight, % change	−5	−0.94
Compression Set—ASTM D395, Method B		
70 hr. at 392°F. (200°C.), %	30	13
336 hr. at 392°F. (200°C.), %	55	32



Gasoline pump metering shaft seal— VITON* fluoroelastomer since 1958.

*Reg. U.S. Pat. & Tm. Off.

fluid resistance of VITON fluoroelastomer

Products made from VITON* fluoroelastomer are successfully used in contact with a great variety of fluids, in many instances at temperatures far higher than are practical with other elastomers. The choice of premium-priced VITON is justified by its trouble-free service which saves far more expensive maintenance and downtime costs.

To assist design engineers concerned with specifying rubber components exposed to severe chemical environments, the accompanying tabulation has been prepared. It includes evaluations of the fluid resistance of VITON versus a selection of materials whose influences, at various temperatures and for certain exposure times, range from virtually no effect on, to complete solution of, products made from properly compounded VITON.

We emphasize that it should be used *as a guide only*. The tabulation is based on laboratory tests and records of actual service performance. But an elastomer's degree of compatibility with a particular fluid also depends on such variables as temperature, time, velocity of flow, aeration, stability of the fluid, degree of contact, nature of suspended solids, etc.

It is always advisable to test the product under actual service conditions before specification. If this is impractical, then tests should be devised which simulate actual service conditions as closely as possible. Obviously, your rubber supplier should be provided with complete details on the conditions involved, since correct compounding and processing are important to the success of any resilient part where chemical resistance is one of the service requirements.

Rating Key

- A—Little or no effect
- B—Minor to moderate effect
- C—Severe effect, ranging to complete destruction
- T—No data—likely to be compatible
- X—No data—not likely to be compatible

Chemical	Rat
Acetaldehyde	C
Acetic acid, 20%	C
Acetic acid, 30%	C
Acetic acid, glacial	C
Acetic anhydride	C
Acetone	C
Acetylene	
Aluminum chloride solutions	
Aluminum sulfate solutions	
Ammonia, anhydrous	C
Ammonium chloride solutions	
Ammonium hydroxide solutions	
Ammonium sulfate solutions	
Amyl acetate	C
Amyl alcohol	A(21
Aniline	A
Aniline	B(15
Aniline	C(30
ASTM oil #1	A(30
ASTM oil #3	A(35
ASTM reference fuel A	
ASTM reference fuel B	
ASTM reference fuel C	
Asphalt	A(40
Barium hydroxide solutions	
Beer	
Benzaldehyde	
Benzene	B(15
Benzoyl chloride	
Borax solutions	
Boric acid solutions	
Bromine, anhydrous liquid	A(21
Butane	
Butyl acetate	
Butyraldehyde	
Butyric acid	
Calcium bisulfite solutions	
Calcium chloride solutions	
Calcium hydroxide solutions	
Calcium hypochlorite, 5%	
Calcium hypochlorite, 20%	B(15
Carbon bisulfide	
Carbon dioxide	
Carbon monoxide	
Carbon tetrachloride	A(15
Castor oil	
Chlorine gas, dry	A(21
Chlorine gas, wet	
Chloroacetic acid	
Chlorobenzene	
Chloroform	
Chlorosulfonic acid	
Chromic acid, 10-50%	
Citric acid solutions	
Copper chloride solutions	

*Reg. U.S. Pat. & Tm. Off.

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- T—No data—likely to be compatible
- X—No data—not likely to be compatible

Chemical	Rating
Acetaldehyde	C
Acetic acid, 20%	C
Acetic acid, 30%	C
Acetic acid, glacial	C
Acetic anhydride	C
Acetone	C
Acetylene	A
Aluminum chloride solutions	A
Aluminum sulfate solutions	A
Ammonia, anhydrous	C
Ammonium chloride solutions	A
Ammonium hydroxide solutions	A
Ammonium sulfate solutions	A
Amyl acetate	C
Amyl alcohol	A(212°F.)
Aniline	A-B
Aniline	B(158°F.)
Aniline	C(300°F.)
ASTM oil #1	A(300°F.)
ASTM oil #3	A(350°F.)
ASTM reference fuel A	A
ASTM reference fuel B	A
ASTM reference fuel C	A
Asphalt	A(400°F.)
Barium hydroxide solutions	A
Beer	A
Benzaldehyde	C
Benzene	B(158°F.)
Benzoyl chloride	B
Borax solutions	A
Boric acid solutions	A
Bromine, anhydrous liquid	A(212°F.)
Butane	A
Butyl acetate	C
Butyraldehyde	C
Butyric acid	T
Calcium bisulfite solutions	A
Calcium chloride solutions	A
Calcium hydroxide solutions	A
Calcium hypochlorite, 5%	A
Calcium hypochlorite, 20%	B(158°F.)
Carbon bisulfide	A
Carbon dioxide	A
Carbon monoxide	T
Carbon tetrachloride	A(158°F.)
Castor oil	A
Chlorine gas, dry	A(212°F.)
Chlorine gas, wet	A
Chloroacetic acid	C
Chlorobenzene	A
Chloroform	A
Chlorosulfonic acid	C
Chromic acid, 10-50%	A
Citric acid solutions	A
Copper chloride solutions	A

*Reg. U.S. Pat. & Tm. Off.

Chemical	Rating
Copper sulfate solutions	A
Cottonseed oil	A(300°F.)
Creosote oil	A(212°F.)
Cyclohexane	A
Dibutyl phthalate	B
Diethyl sebacate	B
Dioctyl phthalate	B
DOWTHERM A	A(212°F.)
DOWTHERM A	B(400°F.)
Epichlorohydrin	C(122°F.)
Ethyl acetate	C
Ethyl alcohol	A
Ethyl chloride	A
Ethyl ether	B
Ethylene dichloride	A-B(120°F.)
Ethylene glycol	A(250°F.)
Ethylene oxide	C(158°F.)
Exxon 2380 turbo oil (lubricant)	A(392°F.)
Ferric chloride solutions	A
Fluosilicic acid	T
Formaldehyde, 40%	A
Formic acid	C(158°F.)
FREON†-11	B
FREON-11	T(130°F.)
FREON-12	A-B
REON-12	B(130°F.)
REON-22	C
FREON-22	X(130°F.)
FREON-113	A
FREON-113	T(130°F.)
FREON-114	A
FREON-114	T(130°F.)
Furfural	C(158°F.)
Fyrquel 220 (hydraulic fluid)	A(212°F.)
Gasoline	A
Glue	A
Glycerin	A(250°F.)
n-Hexane	A
Hydrazine	C
Hydrochloric acid, 20%	A
Hydrochloric acid, 20%	A(230°F.)
Hydrochloric acid, 37%	A(158°F.)
Hydrochloric acid, 37%	B(230°F.)
Hydrocyanic acid	A
Hydrofluoric acid, 48%	A(212°F.)
Hydrofluoric acid, 75%	B(158°F.)
Hydrofluoric acid, anhydrous	A
Hydrogen	A
Hydrogen peroxide, 90%	A
Hydrogen peroxide, 90%	C(270°F.)
Hydrogen sulfide	B(270°F.)
Isooctane	A
Isopropyl alcohol	A
Isopropyl ether	C
JP-4	A(400°F.)
JP-5	A(400°F.)
JP-6	A(100°F.)
JP-6	B(550°F.)
Kerosene	A(158°F.)
Kerosene	B(400°F.)
Lacquer solvents	C
Lactic acid	A
Linseed oil	A
Lubricating oils	A(158°F.)
Magnesium chloride solutions	A
Magnesium hydroxide solutions	A
Mercuric chloride solutions	A
Mercury	A
Methyl alcohol	A-B
Methyl ethyl ketone	C
Methylene chloride	B(100°F.)
Mineral oil	A
Mobil XRM 206A (aircraft eng. lube)	A(350°F.)
Naphtha	A(158°F.)
Naphthalene	A(176°F.)
Nitric acid, 10%	A
Nitric acid, 30%	A
Nitric acid, 60%	A
Nitric acid, 70%	A
Nitric acid, 70%	B(100°F.)
Nitric acid, red fuming	B
Nitric acid, red fuming	C(158°F.)
Nitrobenzene	B
Oleic acid	B
Oleum, 20-25%	A
Palmitic acid	A
Perchloroethylene	A(212°F.)
Phenol	A(212°F.)
Phenol	B(300°F.)
Phosphoric acid, 20%	A
Phosphoric acid, 60%	A(212°F.)
Phosphoric acid, 70%	A
Phosphoric acid, 85%	A
Pickling solution (20% nitric acid, 4% HF)	A
Pickling solution (17% nitric acid, 4% HF)	A
Pickling solution (17% nitric acid, 4% HF)	C(225°F.)
Picric acid	A
Potassium dichromate solutions	A
Potassium hydroxide solutions	A
Pydraul 312C	A
Pyridine	C
QFI-2023 (silicone brake fluid)	A(392°F.)
SAE #10 oil	A
Sea water	A
Shell turbine oil 307	B(392°F.)
Silicone grease	A
SKYDROL 500	C
SKYLUBE 450	C(392°F.)
Soap solutions	A
Sodium chloride solutions	A
Sodium dichromate, 20%	A
Sodium hydroxide, 20%	A
Sodium hydroxide, 46½%	A
Sodium hydroxide, 46½%	C(100°F.)
Sodium hydroxide, 50%	C
Sodium hydroxide, 73%	C
Sodium hypochlorite, 5%	A
Sodium hypochlorite, 20%	B(158°F.)
Sodium peroxide solutions	A
Soybean oil	A(250°F.)
Stannic chloride	A
Stannous chloride, 15%	A
Steam (see water)	B(300°F.)
Stearic acid	T
Styrene	A
Sulfur, molten	A(250°F.)
Sulfur dioxide, liquid	A
Sulfur dioxide, gas	A
Sulfur trioxide	A
Sulfuric acid, up to 5%	A
Sulfuric acid, 5-10%	A
Sulfuric acid, 10-50%	A
Sulfuric acid, 50-80%	A
Sulfuric acid, 60%	A(250°F.)
Sulfuric acid, 90%	A(158°F.)
Sulfuric acid, 95%	A
Sulfuric acid, 95%	A(158°F.)
Sulfuric acid, fuming (20% oleum)	A
Sulfurous acid	A
Sunoco XS-820 (EP lubricant)	A(300°F.)
Tannic acid, 10%	A
Tartaric acid	A
Tetrahydrofuran	C
Toluene	B(100°F.)
Tributyl phosphate	C(212°F.)
Trichlorethylene	A
Trichloroethylene	B(158°F.)
Tricresyl phosphate	A(300°F.)
Triethanolamine	C
Trisodium phosphate solutions	A
Tung oil	A
Turpentine	A(158°F.)
Water	A(158°F.)
Water	A(212°F.)
Xylene	A
Xylene	B(158°F.)
Zinc chloride solutions	A

†Freon is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)

CONVERSIONS FOR EXPOSURE TEMPERATURES INDICATED IN TABLE

°F.	°C.	°F.	°C.	°F.	°C.	°F.	°C.
100	38	158	70	230	110	350	176
120	49	176	80	250	121	392	200
122	50	212	100	270	132	400	204
130	54	225	107	300	149	550	288

FOR FURTHER INFORMATION

Du Pont supplies raw VITON* fluoroelastomer to leading rubber manufacturers throughout the world. They, in turn, fabricate stock items as well as custom parts of VITON and sell through local rubber goods suppliers or direct to end users.

To obtain more information on VITON, contact your normal source of supply for rubber products or write to Du Pont for a list of manufacturers who produce these items. (Please be sure to indicate the particular products in which you are interested.)

If you wish to evaluate VITON for a custom rubber product or for a new application, contact the Elastomers Division District Office nearest you. A sales-service engineer will welcome the opportunity to discuss your application and can refer you to a rubber manufacturer with the facilities and experience required to follow your project to completion.

* Reg. U.S. Pat. and Tm. Off.

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DU PONT

E-46315

Printed in U.S.A.

REFERENCE # 82

SOURCE : MEQ -1

TELEPHONE CALLS

MECHANICAL EQUIPMENT QUALIFICATION

REFERENCE #82

FROM D. Wright OF Gulf (Chevron) JOB NO. TIME

TO BT

ITEMS OF DISCUSSION	ACTION REQ'D. (INCLUDE NAMES & DATES)
Chevron NL Gear Compound 460 oper temp : Pour pt +25°F to 160F Gulf Harmony - hydraulic Fluids usually need Visc not higher than 4000 ¢ not lower than 70 HD 220 oper temp (same as NL Gear Compound) : Pour pt. +25°F to 160°F	1/9/86 G 3c

TELEPHONE CALLS — PAGE 2 of 19

FROM D. Wright OF Gulf/Chevron
TO E.T OF BECHTEL

FILE | DATE
JOB NO. | TIME

ITEMS OF DISCUSSION	ACTION REQ'D. (INCLUDE NAMES & DATES)
Of the 5 products Gulf/Chevron Research Lab has extended the test results for:	
EP Lubricant HD 220 → same radiation tendencies as EP Lubricant HD 150 (tested) (ALL)	
Gulf Crown Grease → same reactions/rad. tendencies as Gulf Crown Grease #2 (tested) (ALL)	
Gulf Crown EP Grease → same reactions/rad. tendencies as Gulf Crown EP #2 Grease (tested) (ALL)	
Gulf Harmony → same reactions as Gulf Harmony #46 & #115 (tested) (ALL)	
Gulf Harmony AW → same rad. tendencies as Gulf Harmony #32 AW (tested)	
—	
Seneca Oils (none)	
Dexron A.T.F (none) no test data & different from any Gulf that has been tested.	
Super Duty Plus (none)	
Lubcote-U (none) no products like it.	
→ discontinued & have to look at particular application for a replacement	
	1/14/86

0046 (2-75)

10.00

Gulf Oil Products Company

HOUSTON MARKETING DISTRICT

P O Box 4256
Houston TX 77210

December 11, 1985

Bechtel Power
c/o Mr. Baldwin Toy (Mail Stop 221/5/A44)
P. O. Box 3965
San Francisco, California 94119

Dear Mr. Toy:

Our November 27th telephone conversation identified three needs as follows:

1. Product brochure for Gulf Precision Grease.
2. A definition of complex as used in defining thickeners in grease.
3. Gulf Harmony 150D - our brochure SP15589-882 indicates an operating temperature of 40 - 130°F where your requirement is 38° - 150°F.

Gulf Precision Grease - Gulf ceased manufacture of this sodium soap type grease in 1979, however, the properties of this product are described in the attached product bulletin. As a general rule, we recommend a Gulfcrown Grease (lithium soap type) of the same consistency to replace Gulf Precision. Sodium soap greases, in general, do not exhibit good compatibility with other greases. Therefore, we recommend that any sodium soap grease be removed before introducing any other type of grease. Short of totally dismantling a piece of equipment, purging can be accomplished by pulling plugs and applying new grease until fresh new grease appears.

Grease Thickeners - Numerous chemical compounds have been used in lubricant formulation as thickeners to produce a solid or semi-fluid product which we call a grease. A petroleum based grease, then, is the product of a finely dispersed solid (the thickener) in a lubricating oil. The chemistry discussion below focuses on soap thickened and soap complex thickened greases in layman's terms; it is not a recipe for making grease nor does it address the properties imparted by the various thickeners.

The thickener in a soap-type grease is produced by a chemical reaction between a fat or fatty acid and an alkali such as sodium, lithium hydroxide. The reaction is called saponification and the soap takes its name from the kind of hydroxide used. Chemically these soaps are call hydroxysterates.

Soap complex thickeners were the result of efforts to improve the heat resistance of soap-type greases. They are produced by further reaction(s) of the soap thickener with other chemicals. Numerous complexes are possible and I have not attempted to list their chemical names.

Harmony 150D - Our brochure indicates that Gulf Harmony Oils fully meet a requirement for hydraulic application in which "response should be consistently good over the range of plant temperatures (normally 40°F to 130°F)." Your question as I recall is what is the operating temperature range for Harmony 150D.

Among other attributes, a suitable hydraulic oil must possess good oxidation stability at operating conditions and be between the upper and lower viscosity limits established by hydraulic pump manufacturers (65 to 4,000 SSU at operating temperature are generally accepted to be the outer limits).

In recommending a particular viscosity grade, we try to choose an oil that will satisfy the equipment manufacturer's requirements over the entire range of operating temperatures encountered. Harmony 150D contains a mild detergent and a special high temperature oxidation inhibitor permitting its use at temperatures as high as 175°F. The usual application of Harmony 150D is for paper machine bearings where it's excellent oil/water separation characteristics are required. Using the viscosity parameter above, this oil may be suitable from 65°F to 225°F. At the higher operating temperatures, oxidation stability becomes the controlling consideration for Harmony 150D. Therefore, our preferred operating temperature limits for Harmony 150D as a hydraulic oil is 65°F to 175°F.

Should we need to explore this subject further, I will need more detail as to the application, such as the equipment manufacturer's name, make and model and any oil specification the manufacturer has provided.

I appreciate receiving your questions and the opportunity to provide a timely response.

Very truly yours,

Dave Wright

D. B. Wright
Technical Representative - Marketing

DBW:kc

Gulf Harmony For gear reducers

General Qualities and Characteristics

Refined from the finest crudes, blended with quality additives, Gulf Harmony® oils for gear reducers are formulated especially to meet the requirements of a quality gear lubricant. They offer high film strength, high lubricity, superior chemical stability, and good separation from water. Work-tested additives in Gulf Harmony oils enhance their ability to resist foaming and combat corrosion.

Application Requirements

Disastrous results occur when gears are permitted to operate without adequate lubrication. Operating gear reducers for long periods without using a properly selected lubricant will be equally destructive, if less dramatic. Metal-to-metal contact of the teeth results in rapid wear and eventual failure. A quality lubricant must have the proper fluidity to assure fast distribution of an oil film over the gear teeth that will resist rupture as the teeth slide over each other. The lubricant must be able to operate effectively under varying loads, temperature and speed, and resist invasion of contaminants that threaten chemical stability and long life.

Gulf Harmony oils have all of the physical and chemical properties to make them effective and efficient in meeting the rigid requirements of gear lubrication.

The wide viscosity range of Harmony oils that is available provides the correct fluidity and oil body for each gear speed, pressure and temperature. The tenacity of Gulf Harmony and its high film strength greatly reduces friction and assures a sufficient oil cushion for shock loads. The high chemical stability of Harmony oils amply protects against oxidation and assures durability under continuous circulation and agitation while resisting foaming. They are especially well fortified with rust inhibitors and are outstanding in their ability to quickly and completely separate any moisture occurring from leaks or condensation.

Recommendations

Gulf Harmony 46, 68, 100, 150D, 220 and 320 are recommended for gear reducer applications in line with the general recommendations of AGMA.

American Gear Mfg. Assoc. Lubricant No.	Gulf Harmony Grade
1	46
2	68
3	100
4	150D & 150
5	220
6	320

While these grades meet most requirements, additional Gulf Harmony grades (32, 115, 460 and 680) are available for use in gear reducers.

Harmony 78 E.P. oil is a special grade made for use as a marine-geared turbine lubricant. This oil has E.P. properties to meet Military Specification MIL-L-17331G(Ships) and has been approved by the Navy against this specification. This military specification is often referred to as Navy Symbol Oil 2190-TEP.

Selection of a grade for a particular application involves consideration of a combination of factors including operating speed, loading, temperatures, gearing design, and equipment manufacturers' recommendations. Consult with your Gulf representative regarding which Harmony grades are correct for your particular applications.

Typical Properties

Gulf Harmony	32	46	68	100	115	150D	220	320	460	680	78 EP
Former Designation	44	47	53	90	69	75	88/97	121	151	204	59EP
ISO Viscosity Grade	32	46	68	100	—	150	220	320	460	680	—
Gravity: °API	31.4	30.5	29.9	29	28.7	28.1	27.3	26.6	25.8	25.3	29.1
Viscosity, kinematic:											
cSt 40°C (104°F)	29.08	42.35	62.5	92.0	116.5	138.9	205	301	465	709	80.1
100°C (212°F)	5.09	6.46	8.34	10.78	12.41	14.04	18.22	23.42	31.12	41.13	9.70
Viscosity, SSU											
100°F	150.3	218	323	478	610	728	1084	1598	2492	3826	416
210°F	43.3	47.9	54.3	63.1	69.3	75.8	93.4	116.6	152.5	200	59.1
Viscosity Index, ASTM D 2270	102	101	102	100	97	97	97	97	97	97	98
Flash,OC: °F	410	425	450	480	500	505	515	540	560	590	475
Fire,OC: °F	465	490	515	535	560	575	585	600	630	660	545
Pour: °F	+5	+5	+10	+10	+10	+5	+5	+5	+5	+5	+10
Color, ASTM D 1500	L0.5	L0.5	L1.0	L1.5	2.0	L3.0	L4.0	L5.0	L6.0	L7.0	L1.5
Carbon Residue, Ramsbottom: %	0.07	0.07	0.08	0.10	0.11	0.42	0.51	0.62	0.73	0.80	0.03
Neutralization Value ASTM D 974, Total Acid No.	0.10	0.10	0.10	0.10	0.10	0.15	0.15	0.15	0.15	0.15	0.16

Ask the pro from Gulf

Gulf Oil Corporation
P.O. Box 1563
Houston, Texas 77251

SP 15590-882

Gulf Harmony For hydraulic systems

General Qualities and Characteristics

Gulf Harmony® oils possess the properties necessary to act as a force-transmitting fluid in modern hydraulically actuated machinery. These include: excellent air-release characteristics, high viscosity index, stability in long-term service and ability to protect metal parts against rust and corrosion.

Application Requirements

Basically, all oils have the ability to transmit force, but modern hydraulic equipment imposes environmental operating conditions which require special attention. Not every oil will do. The oils most suited for hydraulic applications meet these requirements:

1. Response should be consistently good over the range of plant temperatures (normally 40°F to 130°F). Hydraulic oil should not thicken excessively at the low range of temperatures, nor thin significantly at the high end of the scale.
2. Oil should resist deterioration over long service periods.
3. It should protect system elements against rust and corrosion.
4. It should resist foaming and air entrainment.

Gulf Harmony oils fully meet these requirements. With Harmony in a hydraulic system, response is dependable. A selected foam suppressant additive gives Harmony oils excellent air-release characteristics. This eliminates the possibility of spongy, mushy control which results with air entrainment. Consistently positive control is further enhanced because of Harmony's high viscosity index. They maintain their viscosity over a wide temperature range, not thinning significantly with heat nor thickening with cold.

Harmony oils are triple inhibited with highly effective additives, making them exceptionally stable in service. They resist change in character—such as sludging, darkening and acid formation—with time and service. They offer a high degree of rust and corrosion protection, passing Procedures A and B of the ASTM D 665 method for determining rust preventing characteristics of oil.

Recommendations

Gulf Harmony 22, 32, 46, 68, 100 and 150 represent a range of viscosities to meet the requirements of the vast majority of hydraulic systems. In selecting the correct viscosity grade to use, the manufacturer's recommendations and specifications should be reviewed. This is most important because tolerance in hydraulic systems is more critical than in most mechanical industrial equipment. Every system requires a particular viscosity because of its design and the specific conditions under which it operates.

Your Gulf representative will be happy to help you interpret manufacturers' specifications in terms of the right Harmony grade for your hydraulic systems.

Note: For heavy duty hydraulic service and for alternate recommendations for systems in normal service, Gulf Harmony AW oils are recommended. These oils have an added effective anti-wear agent. See separate data sheet.

Typical Properties

Gulf Harmony	22	32	46	68	100	150
Former Designation	41	44	47	53	90	77
ISO Viscosity Grade	22	32	46	68	100	150
Gravity: °API	32.3	31.4	30.5	29.9	29	28.3
Viscosity, kinematic: cSt						
40°C (104°F)	21.36	29.08	42.35	62.5	92.0	145
100°C (212°F)	4.19	5.09	6.46	8.34	10.78	14.25
Viscosity, SSU						
100°F	112	150.3	218	323	478	762
210°F	40.4	43.3	47.9	54.3	63.1	76.7
Viscosity Index, ASTM D 2270	96	102	101	102	100	95
Flash, OC: °F	400	410	425	450	480	505
Fire, OC: °F	445	465	490	515	535	565
Pour: °F	+10	+5	+5	+10	+10	+5
Color, ASTM D 1500	L0.5	L0.5	L0.5	L1.0	L1.5	L3.0
Carbon Residue, Ramsbottom: %	0.06	0.07	0.07	0.08	0.10	0.10
Neutralization Value, ASTM D 974, Total Acid No.	0.10	0.10	0.10	0.10	0.10	0.10
Aniline Point: °F	214	220	223	231	240	246

Ask the pro from Gulf

Gulf Oil Corporation
P.O. Box 1563
Houston, Texas 77251

SP 15589-882

Gulfgem Grease
long life multi-purpose lubricant

General Qualities and Characteristics

Gulfgem Grease is a versatile, multi-purpose grease for elevated temperatures, high speeds and extended lubrication intervals.

Performance testing demonstrates it is an outstanding lubricant for anti-friction bearings, under extended periods at 350° F and remains functional at temperatures as low as minus 20° F. Gulfgem Grease maintains its consistency under shear even at intermittent temperatures of 400° F., however lubrication intervals should be shortened to approximately one-tenth of those at 350° F.

Application Requirements

The Gulf patented aryl diurea thickener in Gulfgem provides unique advantages over conventional soap-based greases. It is an outstanding lubricant for ball and roller bearings at relatively high temperatures and speeds, and has outperformed lithium complex greases and calcium complex greases in difficult applications. In bearing life performance tests run at 10,000 rpm and 350° F under light load, Gulfgem Grease lubricated for over 1300 hours before bearing failure, which was five times longer than competitive polyurea greases tested. Gulfgem has performed well in tests for water spray-off, water leaching and water washout.

Gulfgem has also proved to contribute to low noise levels in bearings.

In applications where clay-thickened, aluminum complex, calcium complex, and sodium soap grease have previously been used, care should be taken to avoid contamination of Gulfgem Grease as these products have been found incompatible with aryl diurea thickened greases.

Recommendations

Gulfgem Grease is recommended for all types of grease-lubricated plain and anti-friction bearings, especially pre-packed and sealed-for-life bearings operating at elevated temperatures and/or high speeds and where contact with water is likely. Gulfgem is suitable in applications involving moderate to high speeds and moderate loads.

The properties of Gulfgem Grease make it particularly suitable for dryer roll bearings, oven conveyor bearings, rotary steam joints, induced draft fan bearings, electric motor bearings, commercial roof-top air conditioning units and equipment adjacent to high radiant heat sources.

Its operating extremes make it possible to consolidate inventories which include more than one grade of grease.

Typical Properties

Dropping Point: C(F)	288 (550)	
Penetration, D-217		
Unworked	270	
Worked 60 Strokes	285	
Worked 10,000 Strokes	308	
Color, Visual	Cream	
Texture	Smooth-Buttery	
Rust Prevention, D-1743	Pass (No. 1 Rating)	
Wear Test, 4-Ball, D-2266		
Ave. Scar diameter: mm	0.32	
EP Test, 4-Ball, D-2596		
L. W. I.	49.6	
Weld Point: kg	400	
Water Washout, D-1264		
Loss at 37.8C (100F): %	0.5	
Loss at 74.4C (175F): %	1.0	
Leakage Tendencies, D-1263 (Mod.)		
24 hrs., 121.1C (250F)		
Total Leakage: g	0.5	
Oxidation Stability, D-942		
Pressure drop: kPa (psi)		
100 hours	0	(0)
200 hours	6.9	(1)
300 hours	6.9	(1)
400 hours	6.9	(1)
500 hours	13.8	(2)
Copper Strip, FTMS 791-5308		
24 hrs., 100C (212F)	No Corrosion	
Fafnir Fretting Corrosion Test		
GM Method 9096-P		
Weight Loss: mg	2.5	
Ball joint Wear Test, D-3428		
Housing weight loss: mg	7.9	
Brine Sensitivity	Pass (no Squawk)	

Ask the pro from Gulf

Gulf Oil Corporation
P.O. Box 1563
Houston, Texas 77001

Gulfcrown® Grease

General Qualities and Characteristics

Gulfcrown Grease is an amber colored, buttery smooth lithium grease suitable for a wide range of uses. Gulfcrown has very good mechanical stability and excellent oxidation stability, insuring long life. It is specially inhibited against rust and corrosion and has superior resistance to the washing-out action of water. Gulfcrown maintains good pumpability, even in cold weather, and is ideal for centralized grease systems.

Application Requirements

Gulfcrown Grease is suitable for bearing temperatures up to 121.1°C (250°F) and down to − 12.2°C (10°F). The water washout test on the No. 1, 2 and 3 grades shows them to be applicable where water contamination is encountered. The excellent oxidation resistance, as indicated by the low drop in pressure after 500 hours at 99°C (210°F) and under 110 psi of oxygen, indicates longer life in bearings with much less deterioration than greases of lesser quality.

The excellent mechanical shear stability of Gulfcrown allows use where lesser greases might run out of poorly sealed bearings.

Recommendations

Gulfcrown Grease, as a true multipurpose grease, is suitable for applications found throughout industry, such as electric motor bearings, fan bearings, pump bearings and other plain and antifriction applications.

It's recommended for use where water contamination is encountered, and is suitable for bearings operating at temperatures as high as 121.1°C (250°F) or higher if replenished frequently. Its pumpability makes it especially suitable in centralized grease systems, even at low temperatures.

Typical Properties

GULFCROWN GREASE

[illegible]	[illegible] 0	No. 1	No. 2	No. 3
[illegible]				
15.6°C [illegible] F)	0.877	0.879	0.884	0.889
Dropping Point, D-2265, °C (°F)	182(360)	191(376)	193(379)	192(377)
Penetration, D-217				
Unworked	359	321	274	228
Worked, 60 Strokes	362	324	278	228
10,000 Strokes	377	335	286	256
Color		amber		
Texture		buttery smooth		
Copper Strip Test, FTMS 791-5309				
100°C (212°F), 24 h		no corrosion		
Leakage Tendencies, D-1263, Mod.				
(24 Hours, 104.4°C (220°F))				
Total Leakage, g	[illegible]	[illegible]	[illegible]	[illegible]
Deposit on Bearing	[illegible]	[illegible]	[illegible]	[illegible]
Water Washout, ASTM D-1264				
Loss at 37.8°C (100°F), Wt. %	[illegible]	[illegible]	[illegible]	[illegible]
Loss at 79.5°C [illegible], Wt. %	[illegible]	3.0	[illegible]	[illegible]
Rust Preventive Test, D-1743		passes		
Oxidation Stability, D-942				
Pressure Drop, [illegible]				
100 h	[illegible]	2	[illegible]	[illegible]
[illegible]	[illegible]	6	[illegible]	[illegible]
Mobility [illegible]				
[illegible] Steel [illegible]				
Rate of Flow [illegible]				
[illegible]	[illegible]	33.6	32.[illegible]	[illegible]
[illegible]	[illegible]	4.4	2	[illegible]
[illegible]	[illegible]	0.55	0.23	[illegible]
Oil Base Properties				
Viscosity				
[illegible]	[illegible]	183.5	183.5	[illegible]
[illegible]	[illegible]	16.19	16.19	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	850	850	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Ask the pro from Gulf

Gulf Oil Corporation
P.O. Box 1563
Houston, Texas 77001

SP 15154

Typical Properties

GULFCROWN GREASE

[illegible]	[illegible] 0	No. 1	No. 2	[illegible]
[illegible] 15.6°C [illegible]	0.877	0.879	0.884	0.889
Dropping Point, D-2265, °C (°F)	182(360)	191(376)	193(379)	192(37[illegible])
Penetration, D-217				
Unworked	359	321	274	228
Worked, 60 Strokes	360	324	278	228
10,000 Strokes	377	335	286	236
Color		amber		
Texture		buttery smooth		
Copper Strip Test, FTMS 791-5309				
100°C (212°F), 24 h		no corrosion		
Leakage Tendencies, D-1263 (Mod.)				
[illegible]				
Total Leakage, g	[illegible]	[illegible]	[illegible]	0.0
Deposits on Bearing	[illegible]	[illegible]	[illegible]	[illegible]
Water Washout, ASTM D-1264				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Rust Preventive Test, D-1743		[illegible]		
Oxidation Stability [illegible]				
Pressure Drop [illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mobility [illegible]				
[illegible]				
Rate of Flow [illegible]				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	0.55	0.23	[illegible]
Oil Base Propert[illegible]				
[illegible]				
[illegible]	[illegible]	183.5	183.5	[illegible]
[illegible]	[illegible]	16.19	16.19	[illegible]
[illegible]	[illegible]	850	850	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Ask the pro from Gulf

Gulf Oil Corporation
P.O. Box 1563
Houston, Texas 77001

SP 15154

Gulfcrown® Grease E.P.

General Qualities and Characteristics

Gulfcrown Grease E.P. is a multipurpose E.P. grease with a light amber color and smooth buttery texture, available in NLGI consistencies No. 0, 1, 2 and 3. It's a lithium soap thickened grease possessing extreme pressure, excellent load-carrying and antiwear properties in both steel-on-steel and steel-on-bronze applications. In addition, it effectively inhibits against oxidation and rust.

Application Requirements

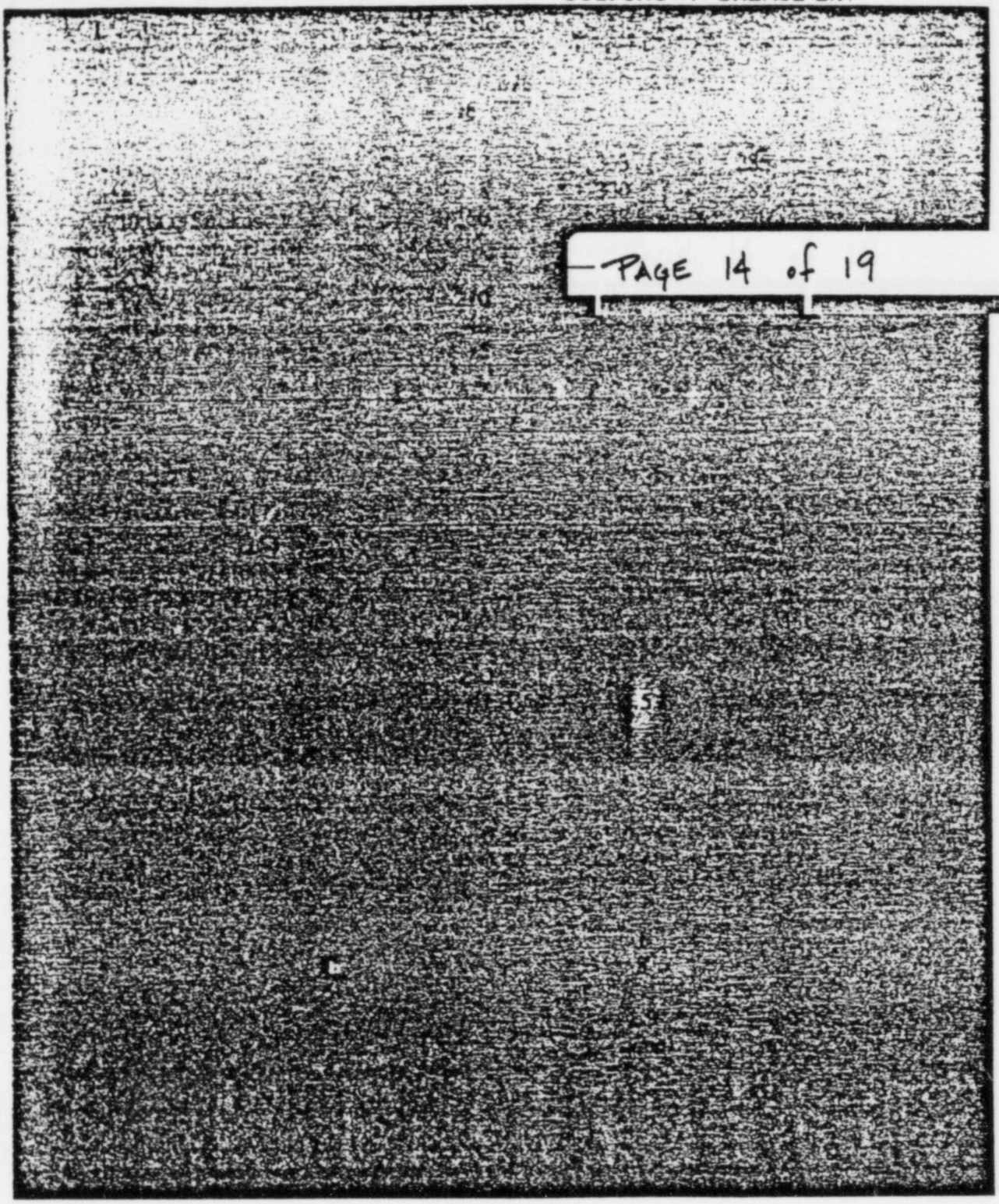
Gulfcrown Grease E.P. has good high temperature characteristics and may be used at temperatures as high as 121.1°C (250°F) or higher if the grease is replenished frequently. Gulfcrown Grease E.P. is suitable for most grease applications where the loads are high, and where shock loads may be encountered, or where, under high pressure conditions, the action of the machine elements are oscillating.

Gulf Recommendations

Gulfcrown Grease E.P. is recommended as a multipurpose grease in many applications. Specifically in such uses as electric motor bearings, fan bearings, and pump bearings, and for those applications where water contamination is encountered. Pumpability is excellent and Gulfcrown Grease E.P. is recommended for service in centralized grease systems. Gulfcrown E.P. No. 0 is recommended for low temperature/low torque applications. Gulfcrown E.P. No. 1 is recommended for centralized pumping systems at temperatures as low as −12°C (10°F). Gulfcrown E.P. No. 2 can also be used in automotive applications when an extreme pressure No. 2 grease is required.

Typical Properties

GULFCROWN GREASE E.P.



Ask the pro from Gulf

Gulf Oil Corporation
P.O. Box 1563
Houston, Texas 77001

SP 15155

Gulf E.P. Lubricants, HD-Series

For Heavy Duty and Oil Mist Applications

General Qualities and Characteristics

Gulf E.P. Lubricants, HD-Series are high quality industrial (sulfur-phosphorus) type gear oils, specifically designed for severe duty conditions. They are produced from high quality base stocks which provide excellent oxidation stability, high viscosity indexes, high flash and low pour points. These lubricants pass all the AGMA requirements for E.P. type gear oils. All grades except Gulf E.P. Lubricant HD680 contain a highly effective stray mist suppressant and are premium quality oil mist lubricants.

Features and Benefits

- Wear Protection
  The modern sulfur-phosphorus additive package protects against scuffing, spalling or welding of mating gear teeth and bearing surfaces under high ambient temperatures or loading conditions.
- Good Demulsibility
  Superior water separating characteristics.
- Wide Temperature Range Performance
  The high quality, paraffinic base stocks provide excellent oxidation stability, high viscosity indexes, high flash and low pour points.
- Formulated for Misting Systems
  Excellent oxidation and thermal stability coupled with a special mist control additive make these lubricants suitable for the most severe misting applications.
- Inventory Control
  One product performing two functions, a premium gear oil and a premium mist oil.

Applications and Recommendations

Gulf E.P. Lubricants, HD-Series meet all the requirements of AGMA Standard Specification 250.04 (September, 1981), for E.P. type gear oils, also those of Cincinnati Milacron, Wheeling-Pittsburgh Steel Corporation, and U.S. Steel Corporation for sulfur-phosphorus gear oils.

Gulf E.P. Lubricants, HD-Series are recommended for the lubrication of bearings and gear drives in extra heavy service. They are recommended for steel mill gear drives which are subjected to large quantities of water, dirt, scale and boundary lubrication.

Though primarily gear lubricants, these oils are suitable for use in many types of plain or antifriction bearings which are subjected to heavy shock loading, overloading or high localized pressures. They may also be used successfully in worm gear lubrication. These HD-Series gear lubricants are especially recommended where extended drain intervals are required.

Gulf E.P. Lubricants, HD-Series are outstanding for mist applications, where shock loading and overloading are encountered. Rolling bearings, plain bearings, slides and ways and chain drives may all be mist lubricated with these products. They minimize reservoir sludging and mist head plugging.

Gulf E.P. Lubricants, HD-Series

Gulf E.P. Lubricant	HD32	HD68	HD100	HD150	HD220	HD320	HD460	HD680
AGMA No.	—	2EP	3EP	4EP	5EP	6EP	7EP	8EP
Gravity: API	30.7	29.1	28.4	27.6	26.9	26.2	25.6	25.1
Viscosity, cSt 40°C (104°F) 100°C (212°F)	30.00 5.39	64.8 8.64	93.0 11.13	138.9 14.41	203 18.48	293 23.42	431 30.05	633 38.43
Viscosity, SUV: s 37.8°C (100°F) 98.9°C (210°F)	154.5 44.3	335 55.3	483 64.4	727 77.3	1070 94.5	1556 116.6	2302 147.4	3405 187.3
Viscosity Index	114	105	105	102	100	99	98	98
Flash, OC, °C (°F)	199(390)	227(440)	229(445)	232(450)	238(460)	243(470)	249(480)	252(485)
Fire, OC, °C (°F)	227(440)	249(480)	257(495)	260(500)	266(510)	274(525)	285(545)	288(550)
Pour: °C (°F)	−18(0)	−18(0)	−18(0)	−18(0)	−18(0)	−18(0)	−18(0)	−12(+10)
Color, D1500	L 3.5	L 3.5	L 4.0	L 4.5	4.5	5.0	L 5.5	5.5
Carbon Residue, Rams., %	0.26	0.26	0.31	0.36	0.40	0.45	0.49	0.65
Neutralization No., D664 Total Acid No.	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Timken Test Lever Load: kg (lb)	29.5(65)	29.5(65)	29.5(65)	29.5(65)	29.5(65)	29.5(65)	29.5(65)	31.8(70)
Rust-Preventive Test, D665, 24 Hr. Procedure A Procedure B	passes passes	passes passes	passes passes	passes passes	passes passes	passes passes	passes passes	passes passes

Ask the pro from Gulf

Gulf Oil Corporation
P.O. Box 1563
Houston, Texas 77251

SP 15363-282

Product Data

Gulf Harmony® AW

For High-Pressure Hydraulic Systems

General Qualities and Characteristics

Gulf Harmony AW oils were developed to provide maximum pump life and trouble-free service in industrial and mobile hydraulic systems. They fulfill the demand of hydraulic pump and hydraulic machinery manufacturers for a premium hydraulic oil. They possess proven protection against wear, outstanding oxidation and thermal stability and are able to satisfy low ambient temperature applications in appropriate viscosity grades. These properties make them suitable for vane, gear or piston type hydraulic pumps, and motors.

Features and Benefits

- EXCELLENT WEAR PROTECTION — Provides highest wear protection, especially with operating pressures in the range of 3000 to 6000 pounds per square inch.
- LONGER FLUID LIFE — The proper combination of high quality base oils and selected additive components provides outstanding oxidation and thermal stability and lower sludge forming tendencies.
- RESIST FOAMING AND ENTRAINED AIR — Reduces equipment noise, spongy or erratic operation and rapid oxidation of the fluid that may result from excessive aeration.
- GOOD DEMULSIBILITY — Harmony AW Oils possess excellent water separation properties, thereby minimizing emulsions which can cause lubrication problems.
- MEETS EQUIPMENT MANUFACTURERS' REQUIREMENTS — Approved by major manufacturers specifying a premium hydraulic oil providing wear protection, oxidation resistance, corrosion and anti-sludge forming tendencies (see inside for more details).
- INVENTORY CONTROL — One hydraulic oil may be used in many varied applications, therefore reducing cost and chances for misapplication.

General Recommendations

Pump Type	Harmony AW
Vane, Gear and Axial Piston Pumps	32, 46 or 68 AW
Oilgear Pumps requiring Heavy Oil	100 AW
Piston Pumps (Radial)	150 AW
Pumps requiring extra Heavy Oil	

In the selection of an oil from this chart, progress to heavier viscosity as operating pressures increase or range of temperature increases. Whenever possible, refer to original equipment manufacturer's recommendation for viscosity grades.

Package Size

Available in bulk and 55 gallon returnable steel drums. Harmony 32AW, 46AW, and 68AW are available in 5 gallon pails.

Oxidation and Thermal Stability

Oxidation of hydraulic fluid can occur at the oil-air interface and within the oil from reaction with dissolved and entrained air. The products of this reaction include weak acids and soaps. Acids can pit metal surfaces; soaps tend to hold moisture which leads to plugged pressure-sensing orifices and flow paths. In addition, moisture-containing soaps tend to reduce the effectiveness of many filtration systems. Another location where high temperature oil oxidation occurs is at the outlet of the pump, where it forms a resinous material that can deposit on hot surfaces (pump rotor, relief valves and spools) causing them to stick. Resinous material forms sludges which combine with dirt and moisture which float around the system plugging small openings in valves and filters and interfere with heat transfer from the reservoir. Gulf Harmony AW Oils provide excellent resistance to the degradation effects of high temperature oxidation.

Wear Protection

Operation pressures in the range of 3000 and 6000 pounds per square inch are now commonly encountered in industrial applications. With these pressures, mechanical tolerances are closer and the need for wear protection characteristics is greater. Gulf Harmony AW provides the highest wear protection for hydraulic systems operating under the most severe conditions.

Gulf Harmony 32AW, 46AW, 68AW, 100AW and 150AW are approved by the Denison Division of Abex Corporation against their HF-0 and HF-2 specifications. The HF-0 approval required that Gulf Harmony AW be pump tested by Denison in a complex hydraulic system using both a large vane and a large axial piston pump. The vane pump was operated at 2,500 psi and the piston pump at 5,000 psi with the oil inlet temperature held at 160°F. for the first seventy hours and then increased to 210°F. to the conclusion of the test at one hundred hours. Both pumps were in excellent condition and showed insignificant wear after one hundred hours of test time.

Gulf Harmony 32AW, 46AW and 68AW are also approved against Cincinnati Milacron Antiwear Hydraulic Oil specifications P-68, P-70 and P-69, respectively. They are recommended for all Cincinnati Milacron equipment requiring either R&O turbine quality or anti-wear type hydraulic oil.

Gulf Harmony AW Oils have passed the Sperry Vickers 35VQ25 high pressure vane pump test where the oil is subjected to 3000 psi and 200°F. The results of this test showed Gulf Harmony AW provided excellent wear protection and these oils can be recommended for use in Sperry Vickers equipment. These oils also show excellent wear protection in the Rexnord "Cyclic" Test utilizing a Racine model "S" pump.

Prevents Foam and Entrained Air

Not only do they resist foaming, they also readily release entrained air. Foaming appears as air bubbles above the surface of the fluid, and entrained air as bubbles below the surface of the fluid. Both situations, if not corrected, may result in spongy, erratic operations, rapid oil oxidation and noise.

Rust Protection

The component surfaces in a hydraulic system are protected against rusting with Gulf Harmony AW Oils. They provide superior rust protection as measured by both procedures A (distilled water) and B (salt water) of ASTM D 665 Rust Test.

Viscosity Range

Five grades of Gulf Harmony AW Oils are available to satisfy the vast majority of hydraulic system requirements. Gulf Harmony 32AW, 46AW and 68AW oils are recommended for the majority of vane, gear and axial piston pumps and motors encountered in industry. The choice of a particular viscosity grade depends on system operating conditions. Most pump manufacturers recommend that certain minimum and maximum viscosity ranges at start-up and during running be maintained. The proper grade for a given system should be chosen so that over the entire temperature range encountered — the start-up viscosity and the operating viscosity range — the pump manufacturer's requirements are met.

Gulf Harmony 100AW satisfies the requirements of certain Oilgear pumps which specify the use of a "heavy" hydraulic oil.

Gulf Harmony 150AW is offered to satisfy the higher viscosity requirements of certain radial piston and special gear type pumps where the manufacturer specifies an oil in the 129.5-194.2 cSt range at 37.8°C. (600-900 SSU range at 100°F.).

Lubrication Applications

Gulf Harmony AW Oils are recommended to handle the more severe hydraulic applications, and will satisfy many lubrication applications, such as machine tools, gear cases and miscellaneous bearing systems, so as to permit a minimum number of lubricants to be inventoried in a plant.

For High Pressure Hydraulic Systems

Typical Properties

	32AW	46AW	68AW	100AW	150AW
ISO Viscosity Grade	32	46	68	100	150
ASTM Viscosity Grade No. (Saybolt)	150	215	315	465	700
Gravity: API	31.2	30.4	29.7	29.0	28.3
Viscosity, Kinematic: cSt					
40°C (104°F)	30.04	42.70	62.9	96	138.2
100°C (212°F)	5.26	6.57	8.43	11.03	14.10
Viscosity, SSU					
100°F	155	220	325	500	724
210°F	43.9	48.2	54.6	64	76
Viscosity Index, ASTM D 2270	106	105	104	99	99
Interfacial Tension, D 971					
77°F :dyn/cm	31	31	31	32	32
Flash, P-M: °F	400	405	450	465	475
Flash, OC: °F	425	430	470	490	500
Fire, OC: °F	455	470	500	545	565
Pour: °F	−25	−25	−20	+5	+5
Color, ASTM D 1500	L1.5	L1.5	L1.5	L2.0	L3.0
Carbon Residue, Ramsbottom: %	0.27	0.27	0.28	0.29	0.33
Rust Preventive Test, ASTM D 665					
Procedure A, 24 hr	Passes	Passes	Passes	Passes	Passes
Procedure B, 24 hr	Passes	Passes	Passes	Passes	Passes
Neutralization No. ASTM D 974					
Total Acid No.	0.50	0.50	0.50	0.50	0.50
Oxidation Test, ASTM D 943					
Time Oxidized					
Hr. to 2.0 Acid No.	2500+	2500+	2500+	2000+	2000+
Emulsion, D 1401, 130°F					
* Test Run at 180°F					
Distilled Water: Minutes	40-40-0 (5)	40-40-0 (5)	40-40-0 (5)	40-40-0 (10)*	40-40-0 (10)*
Aniline Point, ASTM D 611: °F	221	225	232	241	245

Ask the pro from Gulf

Gulf Oil Corporation
P.O. Box 1563
Houston, Texas 77251

SP-15588-882

REFERENCE # 82A

SOURCE : MEQ -1

Chevron U.S.A. Inc.
P.O. Box 4256, Houston, TX 77210 • Phone (713) 827-4800

February 24, 1986

MECHANICAL
EQUIPMENT
QUALIFICATION

REFERENCE # 82A

PAGE 1 OF 2

Mr. Baldwin Toy
Bechtel Power
P. O. Box 3965 (Mail Stop 221/5/A44)
San Francisco, CA 94119

Dear Mr. Toy:

In our February 19 telephone conversation, you requested our thoughts, from a radiation tolerance standpoint, on the suitability of Gulf Seneca 68 in a mild radiation environment possibly as high as 2,000 rads.

I have discussed this application with Mr. G. J. Schreuders at Chevron Research and we do not foresee any difficulty with Seneca 68 in the 2000 rads range.

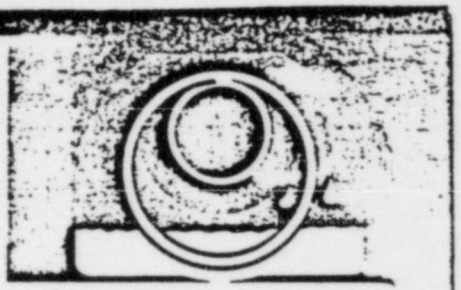
Sincerely,

D. B. Wright
Technical Representative

DBW:pbm

GULF SENECA

For General Purpose Industrial Applications



General Qualities and Characteristics

Gulf Seneca is a non-inhibited mineral oil manufactured from selected naphthenic type crudes. Its low pour point and good oxidation stability are developed by solvent processing and refining. Low carbon residue, freedom from gumming tendencies, and light color are other important properties of this oil. Carbon formed from the combustion of these oils is soft and flaky and therefore easily removed.

Application Requirements

The nine viscosity grades of Gulf Seneca provide an across-the-board capability in general purpose industrial lubrication. They are used effectively for oil lubricated ball and roller bearings; hydraulic and circulating systems; enclosed light-duty, high-speed gears; reciprocating steam engines; machine tools, and general machinery where lubrication is accomplished by ring-oilers, chain-oilers, sight feed cups. bottle oilers, drip cups or hand application; and for certain process applications. Since these products contain no additives, they will not react with or displace the fluid in liquid filled lubricator sight glasses.

Application requirements which most frequently dictate the use of a Gulf Seneca grade, however, are low carbon build-up, soft, flaky characteristics of any carbon that might form, and low temperature operating capability.

The low pour points of all Gulf Seneca grades make them highly desirable in applications involving low starting or operating temperature or where machinery or equipment is subjected to low ambient temperatures.

In applications requiring efficient filtration, Gulf Seneca oils meet all normal conditions. Since they're non-inhibited mineral oils, they may be used with any type filter, including fuller's earth.

Gulf Seneca 45 and Gulf Seneca 49 meet the requirements of Military Specification MIL-L-15016B, Amendment 1, for Military symbol 2110 and 2135 oils, respectively.

Gulf Recommendations

All grades of Gulf Seneca are suitable for hydraulic systems, circulating systems, and general purpose applications requiring a low pour point and good oxidation stability. In particular:

Gulf Seneca 42, 45 and 49 are recommended for refrigeration compressor lubrication where naphthenic type non-inhibited mineral oils are required. Gulf Seneca 49 is being used in both rotary and reciprocating ammonia refrigeration compressors having evaporator temperatures as low as -50 F.

Gulf Seneca 49, 54, and 57 are recommended as compressor lubricants for both low starting temperatures and high operating temperatures where carbon deposits are a critical problem.

Gulf Seneca 39 and 42 have good burn-off characteristics and have proven to be outstanding roll oils for use in Sendzimir mills when rolling both ferrous and non-ferrous metals.

Gulf Seneca oils are eminently suited for use as rubber compounding oils and in other process applications wherever good compatibility, light color, and color stability are required.

The low odor, adhesiveness and viscosity of Gulf Seneca 66 make it suitable for use as an air filter oil on reusable air conditioning filters to capture dirt and dust from the air.

Typical Properties of Gulf Seneca Oils

~~New ISO Viscosity Designation~~	~~22~~ 39	~~32~~ 42	~~46~~ 45	~~68~~ 49	~~77~~ 54	~~100~~ 57	~~150~~ 66	~~180~~ 75	84
ASTM Viscosity Grade(Saybolt)	105	150	215	315	—	465	700	1000	—
Gravity: °API	28.5	27.9	27.0	26.1	26.0	26.1	25.5	25.2	25.0
Viscosity, SUV: Sec. 100 F	110.0	146.6	204.0	305	407	509	766	978	1245
210 F	39.2	41.6	44.8	49.4	53.6	57.8	67.4	75.4	84.6
Viscosity Index	53	53	63	61	60	60	59	61	62
Flash, OC: F	345	355	370	400	400	430	435	455	500
Fire, OC: F	380	390	410	450	445	465	485	515	575
Pour: F below*	—55	—40	—40	—35	—20	—15	—15	—10	—10
Color, ASTM D 1500	L 0.5	L 1.0	L 1.0	L 1.0	1.0	0.5	L 1.5	L 1.5	L 1.5
Carbon Residue, Ramsbottom %	0.06	0.06	0.06	0.07	0.08	0.08	0.09	0.09	0.10
Copper Strip Test 212 F, 3 Hr.	1	1	1	1	1	1	1	1	1
Neutralization Value ASTM D 974 Total Acid No.	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
Aniline Point: F	189	199	203	205	213	216	221	226	229

* "below" applies only to Gulf Seneca 39

Gulf Oil Company—U.S.
Gulf Building
Houston, Texas 77002

Chevron / Gulf

Chevron U.S.A. Inc.
8554 Katy Freeway, Houston, Texas 77024 • Phone (713) 827-4800
Mail P O Box 4256, Houston, TX 77210

January 23, 1986

Bechtel Power
c/o Mr. Baldwin Toy
P. O. Box 3965 (Mail Stop 221/5/A44)
San Francisco, California 94119

Dear Mr. Toy:

This letter is intended to document our several telephone conversations dating back to early December, 1985, to respond to two questions that you posed over this period.

1. Can we predict the effect of radiation on other Gulf products based on previous laboratory work? The products are: Seneca Oils (particularly Seneca 68), Super Duty Plus Motor Oil, Automotive Transmission Fluid - Dexron II, EP Lubricant HD 220, all Gulfcrown and Gulfcrown EP greases, all Harmony Oils, Lubcote and Premium Lubcotes.

2. Can we provide product degradation curves by product or family of products to be used to establish a basis for lubricant change-out intervals? Probably need two curves; one to consider radiation exposure/rust inhibitor loss and a second as a function of operating temperature/oxidation.

First, let's consider predicting radiation effects based on previous laboratory work. On January 13, 1986, I spoke with Mr. Gerard Schreuders at Chevron Research to address this question.

Mr. Schreuders, you may recall, is the author of the report which I sent to you in October titled "Irradiation of Gulf Lubricants - 2nd Edition". In essence, his comments were that laboratory results could be extended to other products of sufficiently similar composition.

Specifically, for the products of concern to you, our position is as follows. EP Lubricant HD 220 should exhibit tendencies under radiation much as EP Lubricant HD 150 which we have evaluated. Other Gulfcrown greases should behave similarly to Gulfcrown Grease No. 2 since the major difference is the quantity of soap; likewise other Gulfcrown EP Grease should behave similar to Gulfcrown EP Grease No. 2. Other Harmony oils (excluding the Harmony AW series) should react similarly to Harmony 46 and 115. Harmony AW oils should react to radiation in much the same way as the Harmony 32 AW test results reported.

We have not tested any products similar to our Seneca Oils, ATF-Dexron II, Super Duty Plus, Lubcote or Premium Lubcote products, therefore, we do not have a basis for predicting the effect of radiation on these products. However, our concerns extend beyond radiation for some of these products and their application in the power plant. The application of automotive type products such as Dexron II and Super Duty Plus (assuming they are not for automotive type equipment) in an industrial plant, causes some concern to me. Our radiation research work did not include motor oils, etc., because we did not anticipate such a need in a nuclear environment. It may be that the application of these automotive products is based on a strict interpretation of the equipment vendor's

- PAGE 5 of 24 -

lubricant recommendation when an industrial lubricant may perform as well, or better, in the specific piece of equipment. In a 1/20/86 conversation you told me that the Super Duty Plus is to be used in a diesel generator in a mild radiation environment, possibly as high as 1,000 rads. We foresee no difficulty with Super Duty Plus tolerating 1,000 rads (not megarads) in this application.

The second question concerns degradation curves. While it may be possible to generate the type of degradation curves which you have requested, we prefer a more generalized approach to lubricant change-out intervals (particularly when due to radiation exposure).

In a nuclear plant, it is our understanding, lubricants are not exposed to large quantities of radiation on a day-to-day basis. Instead, exposure occurs primarily because of some kind of accident such that the exposure is very large for a relatively short duration; obviously these accidents are going to be unpredictable in all aspects - random events. At this point, the other unknown just prior to an accident is the condition of the lubricant in each piece of equipment.

Numerous factors can degrade a lubricant. They include, in no particular order, cumulative radiation exposure, higher operating temperatures, dirt, wear metals, water, contamination from mis-lubrication and others. The best techniques that we have seen employed throughout industry include: 1) a comprehensive preventive maintenance program that includes periodic laboratory testing of lubricants used in key items of equipment and 2) a firm commitment to preventive maintenance throughout the plant management.

Our irradiation testing of Gulf lubricants led to two conclusions. First, all oils should provide sufficient lubricating properties (for their intended application) to permit continued equipment operation for some period of time sufficient, at least, to allow for a safe and orderly plant shutdown, even though some losses have or are occurring in rust protection and oxidation stability. Second, there is no evidence that the lubricants would interfere in any way with shutdown procedures. Therefore, our general recommendation to the nuclear power industry using Gulf lubricating oils and greases is to replace the lubricant as soon as practicable after exposure to 50 megarads and preferably after exposure has reached 10 megarads.

One final comment. On occasion I have mentioned that Chevron has a family of products - NRR Lubricants - which are nuclear radiation resistant. Enclosed is Chevron Technical Bulletin No. 10 for your future reference.

Sincerely,

D. B. Wright
Technical Representative

DBW:kc

Published by Chevron U.S.A. Inc. to report important product technical information.

Chevron Technical Bulletin

Revised
12-20-83

CHEVRON NRR LUBRICANTS

No. 10

Chevron markets a line of Nuclear Radiation-Resistant Lubricants -- currently two oils and four greases -- for use in environments subjected to high radiation dosages. These specialty products have successfully served the nuclear industry since the 1950's. To the best of our knowledge, they are the most radiation resistant of any products of this sort and are the most readily available, certainly in the U.S. if not throughout the non-Communist world.

Because of their expense and limited application, Chevron NRR lubricants are available for sale only through the Central Order Desk, Richmond, CA. Sales are F.O.B. Richmond freight collect -- products will not be shipped until a Purchase Order or Telex is in hand. For information regarding price and availability call (415) 620-2084 or write to:

Chevron U.S.A. Inc.
Central Order Group
P. O. Box 1272
Richmond, CA 94802

The purpose of this Bulletin is to assist in the handling of technical and sales inquiries. Technical questions not covered here should be directed to Chevron Research Company, Marketing Services, 576 Standard Avenue, Richmond, CA 94802 (Telephone (415) 620-3000, Ext. 4079).

Nuclear radiation affects organic lubricants. Any resulting change is generally undesirable because lubricant properties are highly optimized for a given application. Thus, it is important to use radiation-resistant oils and greases in all applications subjected to high doses of destructive nuclear radiation (radiolysis).

Certain general effects are common in the radiolysis of both oils and greases. Chemically, hydrogen and other gases evolve; and unsaturation and cross-linking are produced in the organic molecules. Both low and high molecular weight materials are formed -- the larger molecules predominate. This is reflected physically in an increase in viscosity and ultimate gelation. Greases initially become softer due to attack on the gelling agent. Eventually, they harden as the base oil cross-links.

Encl. - Tables I-VIII
Figures 1 and 2

Limited Distribution
Technical Representatives
Sales Representatives
Others Upon Request

There are many specific radiolysis effects depending upon the composition of a given lubricant. For example, diester synthetic base oils, phosphate esters (antiwear additives), and halogenated materials (EP agents) each produce acids when exposed to low radiation doses. Common polymers such as polybutenes and polymethacrylates cleave readily and thus lose their V.I.-improving function. Silicone antifoam agents are also easily destroyed. The approximate order of radiation stability of organic fluids used in lubricants is shown in Figure 1. High aromatic content promotes radiation resistance.

Other factors also affect stability. An oxidizing atmosphere is bad and increasing temperature lowers the useful life of lubricants. Fluids below polyphenyl ethers in stability in Figure 1 can have radiation resistance improved by including selected additives.

Chevron's nuclear radiation-resistant lubricants are made from alkyl-aromatic-type base oils and contain special additives. They retain their physical properties and lubricating ability over a much wider range of radiation doses than conventional materials.

Conventional soap-gelled, mineral oil-based greases will generally withstand about 10^7 (10 million) rads.[1] Special conventional greases will withstand doses of at least 10^8 (100 million) rads. Much higher doses can be tolerated by the NRR products.

Conventional compounded oils will generally endure more radiation than similar greases, but the oils exhibit wide variations in the doses they will withstand. These variations depend on the base material, the additives used, the exposure conditions, and the performance property being measured.

Our radiation-resistant lubricants are described in Table I.[2] Information on operating limits and recommended uses is included.

Tables II-VIII give pertinent test data.[2]

[1]A rad is a unit of radiation energy absorption:
1 rad = 100 ergs taken up by each gram of absorber = 4.3×10^{-6} Btu/lb.

[2]This information is based on a wealth of data developed previously on similar materials (see Bolt, Carroll; "Radiation Effects on Organic Materials," Academic Press, 1963; Chapter 9, "Lubricants"). Although chemical integrity has been maintained, the actual lubricants offered for sale now are not identical with those originally developed. The present lubricants have not been exposed to tests with radiation. This has not been necessary due to the background cited.

TABLE I

CHEVRON NRR LUBRICANTS

Product	Operating Range, °C (°F)[1]	Radiation Dose Limit 100 Million Rads	Product Description	Recommended Use
Nuclear Radiation-Resistant Greases				
Chevron NRR Grease 159	-23 to 163 (-10 to 325)	30	Premium synthetic aromatic oil, sodium terephthalamate gellant, and selenide oxidation inhibitor.	Antifriction bearings up to 10,000 rpm, motors, pumps, accessories.
Chevron NRR Grease 235	-18 to 93 (0 to 200)	50	Synthetic aromatic oils, silica gellant, and selenide oxidation inhibitor. Also contains graphite and molybdenum disulfide as "residual lubricants."	Low speed, high load sliding surfaces; screw mechanisms; provides residual lubrication in remote machinery, e.g., remote valves.
Chevron NRR Grease 335	-18 to 121 (0 to 250)	50	Synthetic aromatic oils, sodium terephthalamate gellant, and selenide oxidation inhibitor.	Antifriction bearings up to 10,000 rpm; valve activating and screw mechanisms.
Chevron NRR Grease 509	-18 to 93 (0 to 200)	50	A soft version of NRRG-335 containing molybdenum disulfide.	Special product developed for enclosed gear trains.
Nuclear Radiation-Resistant Oils				
Chevron NRR Oil 358	7 to 107 (+20 to 225)	50	25 cSt at 40°C Synthetic aromatic oil plus polymers selected to resist viscosity changes during irradiation; also contains selenide oxidation inhibitor.	Hydraulic pumps and accessory equipment; gear trains; control mechanisms.
Chevron NRR Oil 360	7 to 107 (+20 to 225)	50	280 cSt at 40°C	

[1]In air; can be extended in inert atmosphere.

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RICHMOND, CALIFORNIA

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TABLE II

PROPERTIES OF UNIRRADIATED
CHEVRON NRR GREASES

Test	ASTM Method	Results NRR Grease 159	235	335	509
Worked Penetration, P_{60}	D 217	260	290	290	370
Dropping Point, °C	D 2265	260+	260+	260+	260+
Oil Separation, 25°C, 24 Hr, %	D 1742	0	1.3	2.8	8.7
Oil Separation, 100°C, 30 Hr, %	791-321[1]	1.2	1.7	2.6	28
Four-Ball Weld, kg	D 2596	-	175	-	190
Load Wear Index, kg	D 2596	-	38	-	31
Four-Ball Wear, 20 kg, 54°C, 1800 rpm, 1 Hr, mm	D 2266	-	0.77	-	0.71
Extracted Oil Viscosity: 40°C, cSt	D 445	64	41	35	32
100°C, cSt		9.0	7.2	6.0	5.4
Viscosity Index	D 2270[2]	118	140	115	100
Thin Film Oven Life: 121°C, Days		-	16	39	33
149°C, Days		30	6	12	5
177°C, Days		9	-	-	-

[1]Federal Test Method
[2]J. L. Dreher, "Predicting High Temperature Performance of Lubricating Greases," NLGI spokesman 21, (2) 13 (1957)

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TABLE III

PROPERTIES OF UNIRRADIATED
CHEVRON NRR OILS

Test	ASTM Test Procedure	Typical Results on Chevron	
		NRRO-358	NRRO-360
Viscosity, 40°C, cSt	D 445	25.2	282.8
Viscosity, 100°C, cSt	D 445	4.6	18.4
Viscosity Index	D 2270	91	64
Pour Point, °C	D 97	-7	-12
Flash Point, COC, °C	D 92	138	210
Color	D 1500	6.0	7.0
Copper Corrosion at 100°C	D 130	2C[1]	2C[1]
Sulfur, Mass %	D 2622	0.006	0.005
Evaporation, %, 22 Hr at 100°C		28.4	1.5
Sulfated Ash	D 874	<0.002	<0.002

1

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TABLE IV

TEST DATA ON CHEVRON NRR 159-TYPE GREASE

Radiation Dose, 100 Million Rads	0	7
ASTM Penetration		
Worked 60 Strokes	261	330
Worked 100,000 Strokes	325	307
ASTM Drop Point, °C	260+	260+
Oxygen Bomb		
Copper Corrosion, 100 Hr at 100°C	Slight Stain	Slight Stain
Oxidation, 100 Hr at 121°C, psi Drop	9	24
Water Resistance, % Grease Loss	0	0
Evaporation, %		
22 Hr at 149°C	1.7	3.1
22 Hr at 204°C	21	18.5
Apparent Viscosity, Poises		
0°C at 12 Sec^{-1}	7000	2600
0°C at 20 Sec^{-1}	5000	2000
Low Temperature Torque		
Temperature, °C	-54 | -18 | 4	-54 | -18 | 4
Starting Torque, g-cm	- | 2767 | 554	- | 1106 | 554
Running Torque, g-cm	- | 553 | 185	10,325 | 369 | 344
Navy Gear Wear Test, Wt Loss of Brass Gear		
5 Lb Load, mg/1000 Cycles	2.0	1.8
10 Lb Load, mg/1000 Cycles	5.7	5.0
Bearing Performance		
10,000 rpm, Hr at 149°C (Repeat runs)	1577(634)	306(265)
10,000 rpm, Hr at 177°C (Repeat runs)	400(279;188)	196(196)

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TABLE V

IN-PILE TESTS[1] CHEVRON NRR 159-TYPE GREASE

Motor No.	Time in Materials Testing Reactor, Hours[2]		Radiation Dose,[2] 100 Million Rads
	Total	Irradiated	
31182[3]	1432	1049	14
31183[3]	1432	1049	14
31181	3470	2594	34

[1]Test conditions: 0.3-horsepower motor in vertical position running at 6500 rpm; bearings were about 0.6-inch bore and outside diameter of 1.25 inches; bearing balls and races were M-2 high-speed tool steel with silver-plated separators; bearings were unshielded and were preloaded to 6 pounds; helium atmosphere.

[2]1000 hours represent incident electromagnetic radiation of 1.35 billion rads plus 3.2×10^{16} thermal neutrons/sq. cm, plus 0.64×10^{16} fast neutrons/sq. cm; this roughly corresponds to 1.4 billion rads, ignoring thermal neutrons.

[3]No failure.

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TABLE VI

TEST DATA ON CHEVRON NRR 235-TYPE GREASE

Dose, 100 Million Rads	NRRG-235	
	0	41 to 45[1]
ASTM Penetration Worked 60 Strokes	290	379; 388; 397
ASTM Drop Point, °C	260+	260+
Bearing Performance in Size 204K Ball Bearing, Hr to Failure		
10,000 rpm, 121°C	248	
4,000 rpm, 93°C	3000	
Navy Gear Wear Test, Wt Loss in mg/1000 Cycles		
6000 Cycles at 5 Lb	0.27, 0.22[2]	
3000 Cycles at 10 Lb	0.90, 1.03[2]	
Four-Ball Wear Test 30 Minutes at 800 rpm Scar Diameter, mm		
Steel/Bronze, 2 Lb Jaw Load	0.23	
Steel/Bronze, 5 Lb Jaw Load	0.76	
Steel/Steel, 20 Lb Jaw Load	0.47	

[1]Three separate irradiations; two in air, one in helium.

[2]MIL-G-3278 specification calls for maxima of 2.5 and 3.5, respectively.

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TABLE VII

TEST DATA ON CHEVRON NRR 335[1] TYPE GREASE

Dose, 100 Million Rads	NRRG-335[1]				
	0	4	9	26	30
ASTM Penetration					
Unworked	276	257	238	246	221
Worked 60 Strokes	289	289	308	400	359
ASTM Drop Point, °C	260+	260+	260+	260+	260+
Bearing Performance in Size 204K Ball Bearings, Hr to Failure					
10,000 rpm, 121°C	763; 644				
10,000 rpm, 149°C	220	154	155	-	39

[1]NRRG-509 is a soft grade of NRRG-335. NNRG-509 contains molybdenum disulfide and has an ASTM penetration in the range 360 to 380; the radiation stability of NRRG-509 should be similar although its performance characteristics are different from NRRG-335.

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TABLE VIII

TEST DATA ON CHEVRON NRR 358- AND 360-TYPE OILS

Gamma Dose, 100 Million Rads	Chevron NRR 358-Type Oil				Chevron NRR 360-Type Oil			
	0	4	9	50	0	7	12	52
Appearance of Oil	-	-	Slt. Haze	-	-	Clear	Cloudy	-
Color, ASTM	4-	-	4-	4-1/2	4-	3-1/2	5	8
Appearance of Exposure Can	-	-	OK	-	-	OK	Black	Black
Viscosity cSt at 100°C cSt at 40°C	4.4 26	3.5 20	3.8 22	7.1 72	17 365	11 200	11 200	31 1155
Viscosity Index	85	22	41	43	24	-13	-1	11
Copper Corrosion, 3 Hr at 100°C, Strip Color	1b	2c	2c	2c	1b	2a	2a	1b
Neutralization Number, mg KOH/g Micro	N11	0.10	0.06	0.02	0.01	0.09	0.06	0.01
Four-Ball Wear Test Scar Diameter in mm; 10 kg Load; 30 Min. at 1200 rpm; Steel/Steel	 0.51 0.51	 - -	 0.50 0.57	 - -	 - -	 - -	 - -	 - -
Pour Point, °C	-9	-29	-54	-40	-7	-29	-21	-18
Evaporation, %, 22 Hr at 100°C	31	-	30	-	-	-	-	-

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FIGURE 1

RADIATION RESISTANCE OF BASE OILS

Approximate Gelation Point

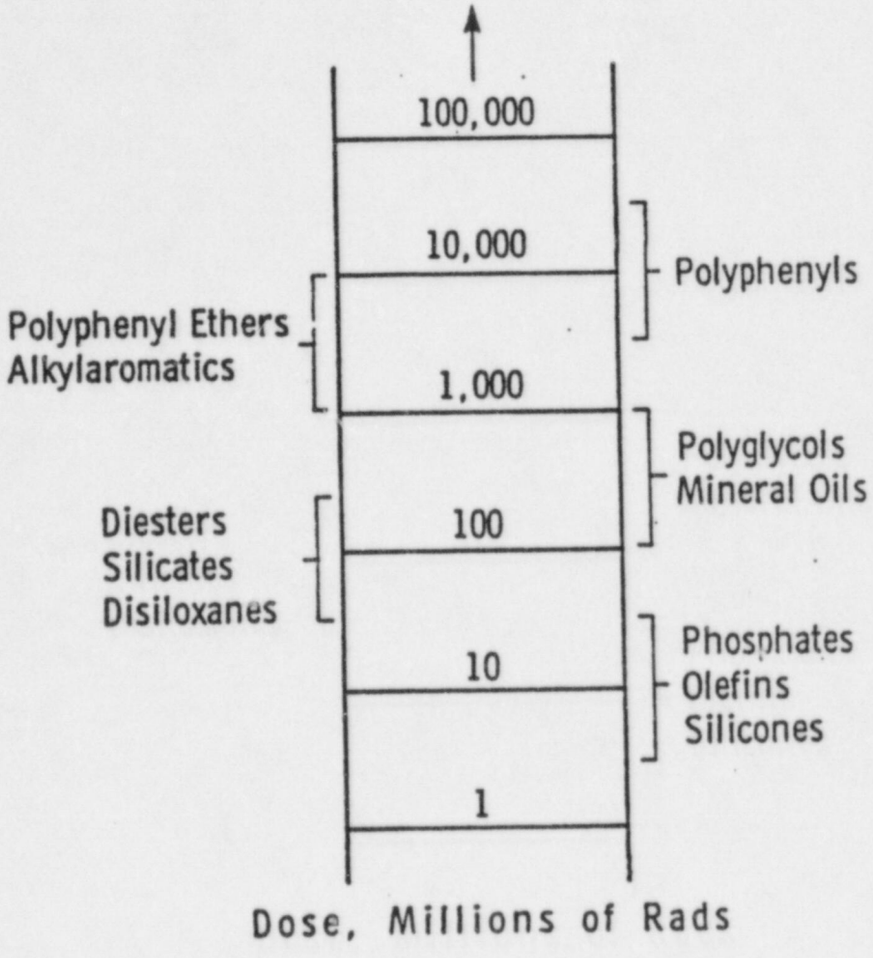

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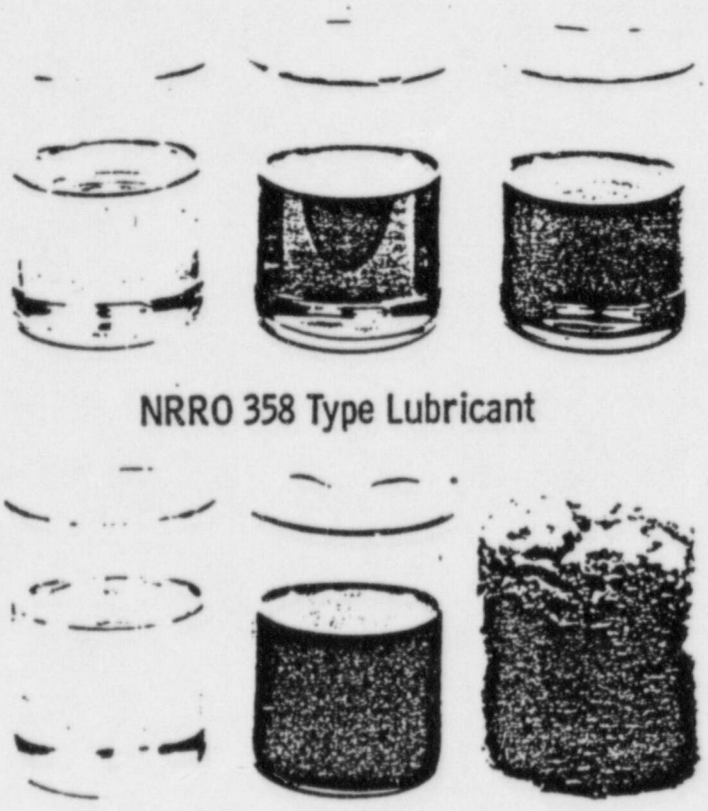
FIGURE 2

GAMMA IRRADIATED OILS



CHEVRON RESEARCH
COMPANY
RICHMOND, CALIFORNIA

E003036

Chevron U.S.A. Inc.
P.O. Box 4256, Houston, TX 77210 • Phone (713) 827-4800

April 7, 1986

Mr. Baldwin Toy
c/o Bechtel Power
P. O. Box 3965 (Mail Stop 221/5/A44)
San Francisco, CA 94119

Dear Baldwin:

As you requested, this letter will document our recent telephone conversations.

In providing you with allowable operating temperature ranges for specific products and applications, I endeavored to satisfy your requirements without extending our products to their outer limits. So, the upper temperatures I provided are somewhat conservative. The ranges are:

A. EP Lubricant HD 68, as a gear oil, operating temperature range is +10°F to 120+°F. You can relate this product to EP Lubricant HD 150 for predicting radiation tolerance.

B. Seneca 68, as a refrigeration oil, operating temperature range from -20°F to 120+°F.

C. Premium Lubcote, as lubricant for cables and chains on air-lock doors, operating temperature range from 0°F to > 550°F. Since the dropping point of the product exceeds 550°F, we can imply that its flash point also exceeds 550°F. Per your conversation with Paul Vartanian, Chevron Research, it has been agreed that the radiation tolerance of Premium Lubcote No. 1 is 5×10^7 rads or higher.

D. Harmony 220, an AGMA #5 product for use in gear reducers, operating temperature is from 15°F to 185°F.

I have enclosed five pages of lubricant recommendations which have been completed. This should bring me up to date in providing responses and documentation which you have requested.

Please let me know when additional lubrication questions arise regarding the South Texas Nuclear Project.

Very truly yours,

D. B. WRIGHT
TECHNICAL REPRESENTATIVE

DBW:pbm

Attachments

Gulf High Temperature Grease

General Qualities and Characteristics

Gulf High Temperature Grease is a calcium-complex lubricant which was developed to meet a growing need for a superior high-temperature petroleum base grease. It is also an outstanding multi-purpose grease, and has proven itself in a wide range of applications.

In addition to its high-temperature performance, Gulf High Temperature Grease exhibits excellent inherent extreme pressure and anti-wear characteristics. These properties are *not* achieved by additive chemicals that must be heat activated but by the nature of a portion of the complex. These inherent E. P. characteristics are therefore much more effective and useful than conventional E. P. systems, since they do not require high heat to be effective. Gulf High Temperature Grease has high affinity for metallic surfaces and excellent water-wash resistance. It has very good mechanical stability and is effectively inhibited against rust, corrosion, and oxidation.

Recommendations

This product has found uses in the steel, paper, rubber refractories, chemical, cement and glass industries. As a further example of its multi-purpose character, Gulf High Temperature Grease is being used in such varied applications as electric motor bearings, laundry and dry cleaning equipment, chip and sawdust cookers, screw conveyors for hot material, molding presses, hot gas fans and blowers, and other applications where high temperature or other adverse conditions require a superior lubricant.

Gulf High Temperature Grease is an NLGI No. 1 consistency. Since it performs satisfactorily over wide temperature and operating extremes, there is little reason for other grades of this particular product — a contribution to simplified lubrication.

Typical Properties

Gulf High Temperature Grease	
Type	**Calcium Complex**
Drop Point F	568
Penetration, ASTM D 217	
Worked, 60 strokes	325
100,000 strokes	348
Color	Beige
Texture	Smooth, Buttery
Corrosion, Copper Strip	
24 Hrs @ 212 F	No Corrosion
Rust Test, ASTM D 1743	1
Oxidation Stability, ASTM D 942	
Pressure Drop, psi	
100 Hr	1
500 Hr	3
Water Washout, ASTM D 1264	
Grease Loss: %	
100 F	4.0
175 F	7.0
Load Carrying Capacity, FTMS 791-6503	
Load Wear Index	53.2
E. P. Test, 4 Ball, 1735 RPM	
10 Sec, 70-80°F	
Weld Point: Kgs	357
Wear Test, 4 Ball, 1800 RPM	
20 Kg., 1 Hr, 130 F	
Avg Scar Diameter: mm	0.325
Avg Coefficient of Friction	0.0741
Timken OK Load, Lbs	50
Mineral Oil	
SUV @ 100 F	600
Viscosity Index	96

Ask the pro from Gulf

Gulf

Gulf Oil Corporation
P.O. Box 1563
Houston, Texas 77001

SP 15444-1181

Gulf Premium Lubcote E.P.
Grades No. 0, 1 and 2

General Qualities and Characteristics

Gulf Premium Lubcote E.P. greases are high dropping point products utilizing a polyurea thickened base grease, and are designed for applications where asphaltic-type lubricants are not recommended or have proved to be less than satisfactory because of high gear speed, high or low operating temperatures and the inconvenience of heating for application.

Special components are included in the products to impart adhesion characteristics necessary in open gear lubricants. Selected additives help them maintain a "grease-like" consistency over a wide temperature range.

Application Requirements

Gulf Premium Lubcote E.P. greases feature excellent water wash-out resistance in addition to good antiwear and E.P. properties. In addition, they are effectively inhibited against rust.

Their adhesion properties are excellent. In a special bench-scale gear adhesion test, they retained from 82-86% of the grease applied, at speeds up to 300 RPM.

They will maintain a "grease-like" consistency at 0°F, which means that they can be applied at low temperature by grease gun, brush or paddle without heating. They have good pumpability and can be applied using air operated grease pumps having a minimum pump ratio of 40:1. In addition, they can also be sprayed using the same equipment and acceptable spray nozzles.

Recommendations

Gulf Premium Lubcote E.P. greases are recommended for application where equipment is subjected to shock and overloading, high or low operating temperatures and when superior adhesiveness is needed. Some typical applications are couplings, fifth wheels, open gears on power shovels, draglines, ball-mills, rotary kilns, and overhead cranes. They are also recommended for use in cam and slide walking mechanisms such as those found on certain large draglines.

Gulf Super Duty Plus

General Qualities and Characteristics

Gulf Super Duty Plus Motor Oil, available in SAE grade 15W/40, provides protection to diesel and gasoline engines operating under the most severe conditions.

It is formulated to meet or exceed the most severe requirements for motor oil, both on-and-off highway. It provides protection over extended drain intervals, and can function extremely well as a single oil in fleets of mixed engine types.

Gulf Super Duty Plus 15W/40 gives effective all-weather protection and easier cold-weather starting. It also contains a friction reducing additive that can yield up to 3% increased fuel efficiency.

Application Requirements

Super Duty Plus is an API CD/SF product that meets engine manufacturers' toughest requirements, and has a Total Base Number (TBN) of 10 as determined by ASTM D 2896. This meets Caterpillar recommendations for an oil to be used when the sulfur content of the diesel fuel is unknown. Super Duty Plus meets Mack EO-K and EO-J specifications; MIL-L-2104 C, MIL-L-46152B; Caterpillar (Former Series 3); Ford M2C-153-B, M2C-157-A; General Motors GM-6049M, GM-6048M; and Cummins. It has a maximum sulfated ash of 1% by weight to meet the requirements of Detroit Diesel and meets the warranty requirements of all U.S. car manufacturers.

Recommendations

Gulf Super Duty Plus Motor Oil is recommended for use in automotive diesel and gasoline engines operated in heavy duty service. It is particularly recommended for supercharged diesel engines, and in off-road construction equipment. Since it meets Caterpillar recommendations for a 10 TBN oil, it is suitable for use when the sulfur content of the diesel fuel is unknown.

Using Gulf Super Duty Plus will satisfy the warranty requirements of nearly all engine manufacturers, and allow operators with several types of engines, and more than one make of equipment, to stock only one engine oil.

Typical Properties

	Super Duty Plus 15W/40
SAE Grade	
Gravity, °API	28.3
Viscosity, cSt, 40°C	99.5
cSt, 100°C	13.56
SUV, 100°F	512
SUV, 210°F	73.7
Viscosity Index	136
Flash, COC, °C	210
°F	410
Pour, °C	−28
°F	−20
Zinc, %	0.134
Sulfated Ash, %	0.93
Total Base No. D-2896	10

Ask the pro from Gulf

Gulf

Gulf Oil Corporation
P. O. Box 1563
Houston, Texas 77001

TELEPHONE CALLS

P.O. 4041/8041

FROM	OF	FILE	DATE
BT	BECHTEL		
TO	OF	JOB NO.	TIME
DAVE WRIGHT (Gulf)	Gulf/Chevron		

ITEMS OF DISCUSSION	ACTION REQ'D. (INCLUDE NAMES & DATES)
(713) 827-4874	
Gulf Harmony #100 pour point = +10F	
For P.O. 4041, application for the starting air compressor of the Diesel Generator. the operating temperature range of 29-104F should be ok using Gulf Harmony #100 since this is not a hydraulic oil application.	A letter will be sent to confirm.
	3/24/86 8:45
Operating Range: Gulf High Temperature Grease - 0 - 325F	
	3/24/86 10:45

TELEPHONE CALLS

FROM	OF	FILE	DATE
Dave Wright	Gulf/Chevron		
TO	OF	JOB NO.	TIME
BT	Bechtel		

ITEMS OF DISCUSSION	ACTION REQ'D. (INCLUDE NAMES & DATES)
Oper. Temp. Range:	
E.P. LUB-HD 68 10F TO 120F	
SENECA #68 -20F TO 120F	
	3/25/86
	2:30

0044 (5-82)

TELEPHONE CALLS

FROM	OF	FILE	DATE
~~BT~~	BECHTEL		
TO	OF	JOB NO.	TIME
D. Wright	Chevron/Gulf		

ITEMS OF DISCUSSION	ACTION REQ'D. (INCLUDE NAMES & DATES)
(713) 827-4874	
Gulf E.P. Lubricant HD 68 is the same as EP Lubricant HD220 where the radiation tolerance levels are equal to E.P Lubricant HD150 as tested.	
Operating Temperature Range for:	Gulf Harmony 220 is 15 to 185F Gulf Premium Lubcote EP is 0-550F 8:30 3/31/86
Paul Vartanian (Chevron Research Lab - 415-620-4749)	
Gulf Premium Lubcote, for radiation evaluation, is similar to normal conventional greases. Therefore, looking at Gulf Crown EP, it is reasonable to assume Gulf Premium Lubcote would probably be the same - 5×10^7 RADS.	10:15 3/31/86

0048 (6-82)

REFERENCE # 90

SOURCE: MEQ-1

TELEPHONE CALLS

MECHANICAL
EQUIPMENT
QUALIFICATION

REFERENCE #90

FROM BT OF BECHTEL

TO Herb Dergan OF SHELL Oil Co.

JOB NO.

TIME

ITEMS OF DISCUSSION	ACTION REQ'D. (INCLUDE NAMES & DATES)
(800) 231-6950	
operating temp for:	
DARINA (ALL/EP) → -20 to 250F	
DARINA #1/EP → -30 to 250F	
VSI (ALL) → 25-150F	w/ 10°F pour Pt.
all petroleum hydrocarbon products	1/13/86 8:30

TELEPHONE CALLS

ROUTE

FROM EJ OF ECHTEL

TO ED MIRONCHIK OF SHELL OIL

FILE | DATE

JOB NO. | TIME

ITEMS OF DISCUSSION	ACTION REQ'D. (INCLUDE NAMES & DATES)
(713) 493-8247	
Alaska EP guises - do not use in electric motor bearings causes damage to the insulation of motors under radiation.	
Lubriplate - Regular (All Grades) - have the same radiation tolerances as results for Alaska #2 (tested)	
Lubriplate Grease - (All) - Levels as in letter However will call back for higher levels.	
	1/13/86 9:00 AM

Technical Bulletin
Shell Oil Company

Alvania® Greases
Premium quality, multipurpose greases

Product line

Shell's Alvania Greases 1, 2 and 3 are smooth-textured, amber-colored greases manufactured with a lithium 12-hydroxystearate soap thickener. They are inhibited with additives to assure long service life, and provide good lubrication and corrosion protection of grease-lubricated parts in both heavy and light industry. Alvania Greases are excellent as general plant and electric motor lubricants. NLGI Grades 1 and 2 are readily pumpable in pressure grease dispensing systems.

Alvania EP Greases R00, R0, 1 and 2 are dark brown in color and are fortified with extreme pressure additives to give increased load carrying properties. They have excellent antirust properties. Alvania EP Greases are an excellent selection for all applications, including heavy or shock loading situations, where bearing temperatures do not exceed 275°F.

Alvania Grease D is a long-life grease for railroad antifriction journal bearings designed for field relubrication as well as those bearings requiring shop or factory relubrication. It is approved against AAR Specification M-942.

Applications

Proper grease selection depends upon many factors, including bearing size, speed, temperature, load and method of application (hand gun, centralized systems). The bearing lubrication guide in this bulletin will assist in this selection.

Antifriction bearing lubrication guide

Operating Temperatures °F	Bearing Speed Factor[1]	Recommended Alvania Grease Grade
-30 to 100	0 to 75,000	1
	75,000 to 150,000	1
	150,000 to 300,000	2
0 to 150	0 to 75,000	2
	75,000 to 150,000	2
	150,000 to 300,000	3
100 to 275	0 to 75,000	2
	75,000 to 150,000	3
	150,000 to 300,000	3

[1]The bearing speed factor is the bearing bore measured in millimeters multiplied by the bearing shaft speed measured in revolutions per minute. For the purpose of converting to millimeters from inches, one inch equals 25.4 millimeters.

Physical properties

Alvania Grease	1	2	3	EP R00	EP R0	EP 1	EP 2	D	ASTM
Shell code number	71011	71012	71013	71039	71030	71031	71032	71024	Method
NLGI grade	1	2	3	00	0	1	2	—	
ASTM worked penetration at 77°F, 60 strokes	325	287	238	423	378	330	285	306	D 217
Dropping point, °F	360	365 ✓	370 ✓	335	350 ✓	360	370 ✓	393	D 566
Timken EP test, lbs. pass	5	5	5	40	35	50	50	5	D 2509
Bomb oxidation, 100 hrs. at 210°F, psi drop	3	6	5	12	12	12	12	3	D 942
Mineral oil viscosity									
SUS at 100°F	314	515	495	725	720	1100	1100	842	D 445
SUS at 210°F	51	59	58	65	66	80	80	76	D 445

Shell Oil Company Lubricants Sales Offices

East Coast (201) 325-5497	100 Executive Drive West Orange, New Jersey 07052
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February 1984

Technical Bulletin
Shell Oil Company

SOC:158-85

Shell *VPI* 260

Volatile corrosion inhibitor

Description

Shell *VPI* 260 is a volatile or "vapor-phase" inhibitor developed by Shell specifically for the protection of iron and steel surfaces against rusting. It is a stable nitrite of an organic amine. A fine white powder, it possesses appreciable vapor pressure at ambient temperatures. *VPI* 260 acts by volatilizing, reaching metal surfaces in the vapor phase, and being adsorbed on the metal to form a normally invisible film which acts to prevent corrosion by passivating the metal.

VPI 260 normally is introduced as a solid, but occasionally as a solution, into an enclosed air space containing the surfaces to be protected. A third method of introduction is by coating or impregnating packaging material. Such *VPI*-treated material is usually wrapping paper and is commercially available from several paper converters.

Methods of application

In principle, the method of using Shell *VPI* 260 is simply to enclose the metal surfaces or articles in a package in which ventilation is absent or severely restricted, and to include in the package sufficient *VPI* 260 to maintain a saturated or near-saturated concentration of the vapor for the period of protection required. For maximum effectiveness the *VPI* crystals should be adequately dispersed within the package and should be within at least one foot of the surface to be protected. No special preparation is necessary except to be sure that the surfaces to be protected are reasonable dry.

Application as a powder

Shell *VPI* 260 may simply be dusted on when the shape of the article to be protected permits adequate distribution and allows the powder to remain on or near the surfaces vulnerable to corrosion. With suitable safeguards industrial floc guns may be used. An alternative or supplementary means of application is to suspend the crystals in small porous bags near the surfaces to be protected.

Application in solution

The application of Shell *VPI* 260 in solution in a volatile solvent such as methy or ethyl alcohol will aid in distributing the material throughout articles with complex shapes. This method also helps to provide rapid protection, since the inhibitor can directly reach the area where it is required. The solvent should be completely evaporated before the package is sealed.

Application as a packaging material

Frequently the most convenient method of applying *VPI* crystals is to use it on packaging materials. Coating or impregnation of paper or board is done under license by several paper converters. Shell Oil Company does not sell coated paper directly. However, Shell sales offices can provide manufacturers' names so that availability and application details may be obtained.

Quantity required

The quantity of Shell *VPI* 260 required to maintain a sufficient concentration of vapor will depend on the efficiency of sealing in a given application. An adequate quantity may be very small where vapor loss is completely prevented. Generally speaking, however, a suitable quantity is two grams (0.07 ounce) per cubic foot of enclosed space or one gram per square foot of metal surface, whichever is the greater. The recommended quantity of inhibitor should be introduced into the confined space regardless of the method used to apply it.

Suggestions to help assure satisfactory performance

1. *VPI* 260 should be used only to protect items that will be packaged or otherwise enclosed.
2. While no special preparation is required, the surfaces to be protected should be reasonably dry.
3. Air-tight packaging is not essential and for some purposes very simple arrangements will suffice, provided that no gaping openings are left.
4. Adequate weather proofing should be provided particularly to insure that water does not penetrate and wash away the inhibitor.
5. Excessively high temperatures should be avoided. The loss of *VPI* 260 from non-air-tight packages will increase sharply above 125° F.
6. Shell *VPI* 260 is virtually insoluble in oil and greases. If it is mixed with such products, the rate of vaporization and therefore the effectiveness is greatly reduced. However, if it can be introduced into the vapor space surrounding a coated or oiled object additional protection may be obtained.
7. Acidic materials tend to decompose *VPI* 260. Strong alkalai will do the same. Therefore acidic packaging material such as partially seasoned timber and some types of paper should not contact the metal being protected from corrosion.
8. The rough surface of cast-iron is generally more susceptible to electro-chemical attack than smooth surfaces. It is recommended that rough cast-iron components of articles to be protected by *VPI* 260 should first be coated with a good quality mineral oil.
9. Shell *VPI* 260 is not specifically designed for preventing corrosion of non-ferrous metals. Its use with lead and cadmium is not recommended because of potential corrosion. Some staining has been observed upon direct contact with brass and copper. With other nonferrous metals, exposure was either without effect or in some cases, gave a slight degree of protection. One notable exception was aluminium, where excellent protection was recorded.
10. Shell laboratories have investigated the effect of the vapors on many non-metallic materials and surface coatings. In most cases there is no effect at all. However, since the possibilities for use are so varied, it may be advisable to carry out a preliminary trial under specific conditions.

Safety precautions

Shell *VPI* 260 has toxicological properties similar to those of sodium nitrite. Excessive exposure can result in headache and a lowering of blood pressure. *VPI* 260 is rated as moderately toxic, and contact with foods for human consumption or with animal feeds must be avoided.

Handling *VPI* 260 under normal conditions does not cause any trouble. However, it is a matter of ordinary prudence to minimize contact with crystals and solutions, just as with many other chemicals. Workers exposed for prolonged periods of time to air containing *VPI* 260 should wear dust masks.

VPI 260 is combustible. If welding is to be performed on vessels or pipes that have been protected internally with *VPI* 260, precautions must be taken to remove the residual crystals prior to welding. This can be accomplished by means of a water wash.

Physical properties

Vapor Pressure at 70° F, mm Hg	0.0001
Solubility at 77° F, Grams per 100 grams of	
solution in water	4
in Methanol	23
in Ethanol	9
in Isopropanol	2
Solubility in water at various temperatures,	
Grams per 100 grams of solution	
at 32° F	3
at 115° F	5
at 150° F	7
Melting Point, °F	390
Flash Point, COC.° F	240

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April 1985

Shell Development Company
A Division of Shell Oil Company

Westhollow Research Center
P O Box 1380
Houston Texas 77001

October 10, 1985

Mr. Baldwin Toy
Bechtel Power
P.O. Box 3965
Mail Stop 221-5/A44
San Francisco, CA 94119

Dear Mr. Toy:

During our recent conversation you requested information as to the radiation resistance and anticipated shelf-life of certain Shell lubricants.

With reference to the VSI® Circulating Oil 32, no irradiation tests have been conducted by Shell. However, with reference to a chapter authored by E. R. Booser of General Electric which appears in the Standard Handbook of Lubrication Engineering, he states that a radiation dose which results in a 25% increase in the viscosity at 100°F can be taken as a tolerance limit. With this guide, the tolerance limit for a light turbine oil is shown to be 1.5×10^8 rads. Since our VSI Oil 32 would meet that definition, we would anticipate its tolerance to be in the same range. The maximum operating temperature recommended for VSI Oil is 150°F. Operation above this temperature rapidly depletes the volatile inhibitors and accelerates oxidation of the oil.

Relative to greases we are supplying details of our radiation testing of Shell DOLIUM® R Grease. This product was irradiated to a level of 2.2×10^8 rads, after which tests were conducted to detect the effects. Certification of the radiation testing showing the dose rate and duration is attached. The radiation source was Cobalt 60.

After being irradiated, DOLIUM R on visual inspection indicated it had maintained its normal grease texture and consistency, with only a slight darkening in color. Penetration tests confirmed the grease consistency to be relatively unchanged. The ASTM D 1743 Rust Test showed rust protection properties were maintained. To evaluate the ability of the grease to lubricate effectively, a test bearing was packed with the irradiated grease and run for a period of 168 hours in a Pope Bearing Rig at 300°F, and performance was found to be satisfactory. The test results are also attached. Duplicate tests were run on an "improved" DOLIUM formulation designed "DR-31" as we anticipate this new version to be adopted after user qualification testing and review. Earlier test results with ALVANIA® Grease 2 showed only a 20% softening after radiation exposure at 4.75×10^8 roentgens in static tests. Thickener systems of the type employed in DARINA greases, a hectoritic clay,

reflect good radiation resistance and would be expected to reflect minor changes, if any, at a dose level of $1x10^6$ rads.

The shelf life of most lubricants can be quite extensive given good storage conditions. As a general rule, a term of 2 years could be utilized for oils and a term of 18 months for greases. The products may be completely satisfactory for use after that period, but should be visually examined for contamination or changes before use. Good inventory control should eliminate the problem of old or contaminated stock.

We trust this information will be useful, Mr. Toy. Thank you for your use of Shell products at the So. Texas Nuclear Project.

Very truly yours,

E. Mironchik
Sr. Staff Research Engineer
Fuels and Lubricants Dept.

EM/awb

Attachments

cc: Shell Oil Company
West Coast Lubricants Sales
District Manager - J. M. Coghlan

Houston Lubricants Sales
District Manager - W. R. Davenport, Jr

NEUTRON PRODUCTS INC
22301 Mt. Ephraim Road, P.O. Box 68
Dickerson, Maryland 20842 USA
301/349-5001 TWX: 710-828-0542

October 14, 1983

Mr. Edward Mironchick
Shell Development Corp.
P. O. Box 1380
Houston, Texas 77001

Dear Mr. Mironchick:

Enclosed please find the radiation test reports for your grease samples. Should you require additional information, or clarification of data presented herein, please do not hesitate to call me at 301-349-5001.

Sincerely,

NEUTRON PRODUCTS, INC.

Elizabeth L. Baker

Elizabeth L. Baker

Enclosure

ELB/kmw

IRRADIATED GREASES
TEST RESULTS

	Original	2.2×10^8 Rads
DOLIUM® R		
1/4 Pen, Unworked	192	226
Worked Pen, 60 Strokes	252	271
ASTM D - 1743 Rust Test	1,1	1,1
Pope Rig, 300°F 168 Hrs.		Normal Operation
"DR-31"		
1/4 Pen, Unworked	294	275
Worked Pen, 60 Strokes	301	301
ASTM D-1743 Rust Test	1,1	1,1
Pope Rig, 350°F 168 Hrs.		Normal Operation

Technical Bulletin
Shell Oil Company

Shell *Darina*® Greases

Superior quality multipurpose greases for lubrication of bearings operating at elevated temperatures.

Product Description

Shell *Darina* Greases are superior quality, multipurpose, non-soap greases. They give excellent lubrication in wet or dry applications, over a wide temperature range and for long periods of time. This performance makes them more versatile than many soap-based industrial greases.

The *Darina* Greases are based on *Microgel*®, a Shell-developed inorganic thickening agent. *Microgel* does not have the limitations of soap-type thickeners. It does not melt, dissolve, or lose its thickening power from sheardown, as soap fibers sometimes do. Because of *Microgel's* superior characteristics, *Darina* Greases can be used in a much wider variety of applications than most soap-base greases.

Darina Greases are available with and without extreme pressure agents. Both versions are made in three National Lubricating Grease Institute (NLGI) consistencies, Grades 0, 1, and 2.

Environmental concerns can be minimized by using either *Darina* or *Darina* EP Greases, because they do not contain lead compounds. Because the non-EP version does not contain any components which the U.S. Department of Agriculture considers particularly toxic, it is approved for use in meat and poultry processing plants where there is no possibility of contact with the food.

Applications

Darina Greases are intended for industrial grease-lubricated machinery particularly where the grease is exposed to temperatures as high as 250° F or, with frequent relubrication, 350° F. *Darina* Greases are well suited to ball, roller, and sleeve bearings as well as to sliding surfaces and grease-lubricated gears. They perform well where water is present because they can adhere to wet parts, resist dissolving in water, and resist its washing action. The extreme pressure version, *Darina* EP Grease, is recommended for heavily loaded machines and is somewhat better in its water resistance.

One of the major industries having a requirement for a grease with these characteristics and therefore one of the largest consumers of *Darina* Greases is the steel industry. Steel mills have heavy machinery and difficult service conditions and therefore use *Darina* EP Grease more often than *Darina*. Steel mills frequently have centralized grease dispensing systems. These systems have distribution lines that are exposed to temperature extremes from winter's cold to radiation from hot steel. The ability to be pumped through piping and tubing under a wide range of conditions is important in the steel industry and is known as grease "mobility." *Darina* EP Grease 1 has good mobility and is especially suited to these conditions.

The *Darina* Greases are also excellent candidates for applications in chemical plants and paper mills where grease is exposed to very wet conditions; mining and process plants where crushers, screens, and kilns are operated at high temperatures; and general industry where a multi-purpose grease can simplify plant lubrication by meeting virtually every grease lubrication need.

Performance Test Results for *Darina* Greases

Oxidation Resistance

Darina Greases owe their oxidative excellence to the fact that they are manufactured using high quality base oils which are further enhanced with an oxidation inhibitor. Oxidation stability is measured in the Bomb Oxidation Test ASTM D942. In this test, a grease sample is placed in a bomb heated to 210° F and filled with oxygen to 110 psi. The Bomb Oxidation Test indicates the tendency for a grease to take up oxygen by measuring the pressure drop of the oxygen, usually after 100 hours. The less the pressure drop during the test, the less prone to oxidation will be the grease. Some less stable greases give pressure drops as high as 28 psi.

Darina Grease

Gave a pressure drop of 10 psi, after 100 hours.

Darina EP Grease

Gave a pressure drop of 1 psi after the 100 hour test and only 4 psi after 500 hours.

These results mean that you may be able to reduce the grease quantity that you feed to the bearings and that *Darina* EP will retain its original characteristics in service for a long time.

Mechanical Stability

The Roll Stability Test, ASTM D1831, simulates grease being worked in a roller bearing. In this test some greases tend to change their consistency — some even become liquid after being churned by the roller. If this occurs in a bearing, it can result in leakage. The change of consistency is measured as a percentage of the original consistency after being tested at room temperature and at 212° F. The less the percentage of change in this test, the greater will be the grease's stability in service.

Darina Grease

The NLGI 2 grade changed 15% after being tested for four hours at room temperature.

Darina EP Grease

Darina EP Greases changed less than 1% after being tested for two hours at room temperature. At 212° F, *Darina* EP 1 changed by 6% and *Darina* EP 2 changed by only 12%.

These results mean *Darina* Greases can be expected to stay on the job, giving lower grease consumption and less frequent relubrication.

Adhesion

Adhesion as a lubrication problem relates most significantly to extreme pressure greases because they are used in heavily loaded applications often in the presence of cooling water. Although adhesion can sometimes be important in dry applications (to stay on gears or wire ropes, for example) tackiness is usually needed to prevent grease from being washed away by rain or cooling spray. In the Water Spray-off Test, water at 100° F and 40 psi is sprayed onto a thin layer of grease. The more the grease stays in place, the better its adhesion in wet service. With *Darina* EP, half of the grease remained, whereas only 10-15 percent was left after the test on another inorganic EP grease.

Water Washout

In addition to the spray-off test, which measures the adhesive properties of grease, *Darina* Greases were subjected to the Water Washout Characteristics Test ASTM D1264. This test evaluates a lubricating grease's resistance to washout from a bearing by water. The test is carried out at 100 or 175° F and at 600 rpm. The percent of the grease sample washed away by water is reported. Shell *Darina* EP Grease showed "nil" loss in the test.

Grease Leakage

The tendency for a grease to leak from bearings in service can be measured in the Wheel Bearing Leakage Test, ASTM D1263. In this test, the grease sample is rotated in a modified automobile front wheel hub at a speed of 660 rpm and at a spindle temperature of 220° F.

Darina Grease

Darina Grease 2 showed no loss by leakage.

Darina EP Grease

A scant 2 grams of *Darina* EP 2 and 5 grams of *Darina* EP 1 leaked from the 90 gram sample at 220° F. This was two-thirds less than leakage with another EP inorganic-thickened grease.

These results show that you can expect long service from *Darina* Greases at elevated temperatures without losing the grease.

Load Carrying Ability

Extreme pressure characteristics are necessary for heavily loaded machines to prevent metal to metal contact that can destroy gears and bearings. Only the *Darina* EP Grease is tested for this property. Several extreme pressure tests are recognized, and the results for *Darina* EP 2 Grease in these tests are given below:

Test	ASTM Test Method	Result
Timken Test, lbs. pass	D2509	50
4-Ball EP Test, Weld Load Kg	D2596	315
4-Ball EP Test, Load Wear Index	D2596	40
4-Ball Wear Scar, mm., 40 Kg, 1800 rpm, 1 Hr.	D2266	0.73

Protection Against Corrosion

The ability of a grease to protect expensive machinery against corrosion is an important consideration especially where the machinery is exposed to high humidity. This property is measured by the ASTM Corrosion Preventive Properties Test, ASTM D1743. In this test, a cleaned and greased bearing is stored for 48 hours at 125° F and 100 percent relative humidity. *Darina* Greases passed this test, which means there are no black stains, pitting, etching, or rusting. No corrosion means lower maintenance and longer machine service life.

High Temperature Performance

High temperature performance was measured in the Federal Test Method 331.2, the Navy Rig Test. This test consists of stressing the grease both thermally and oxidatively in a bearing running at 10,000 rpm and 300° F with a three-pound radial load. The test is run until the bearing fails or binds. *Darina* EP Grease 2 lasted 1,135 hours in this test, compared with a lithium hydroxystearate soap grease at 280 hours.

This performance means that less frequent replenishment of the grease will be required, which can save both grease and maintenance costs. It also means fewer bearings to be cleaned or replaced.

Table 1/**Typical Properties of Shell *Darina*® Greases**

	ASTM Method	Darina Grease 0	Darina Grease 1	Darina Grease 2	Darina EP Grease 0	Darina EP Grease 1	Darina EP Grease 2
NGLI Grade Number		0	1	2	0	1	2
Code Number		71500	71501	71502	71520	71521	71522
Thickener		Microgel®	Microgel®	Microgel®	Microgel®	Microgel®	Microgel®
Color		Amber	Amber	Amber	Amber	Amber	Amber
Appearance		Smooth	Smooth	Smooth	Smooth	Smooth	Smooth
Worked Penetration at 77° F, 60 Strokes, dmm	D217	364	330	280	375	337	288
Worked Penetration at 77° F, 100,000 Strokes, dmm		—	—	—	—	352	332
Dropping Point, °F	D2265	500+	500+	500+	500+	500+	500+
Bomb Oxidation at 210° F Pressure Drop at 100 Hours, psi	D942	—	9	9	1	1	1
ASTM Corrosion Test 14 Days	D1743	No Rust	No Rust	No Rust	No Rust	No Rust	No Rust
Wheel Bearing Test at 220° F, gm	D1263	—	—	Nil	—	5	2
Water Spray-Off 40 psi at 38° C, %		—	—	—	65	54	38
Water Wash-Out at 100° F, % Loss	D1264	—	—	2	7	Nil	Nil
Timken Test, Pounds Pass	D2509	—	—	—	50	50	50
Load Wear Index, Kg	D2596	—	—	—	—	48	50
Mobility, 0° F, g/min.		—	—	—	2.7	1.4	0.6
Lincoln Ventmeter Test: 30° F, psi		—	—	—	190	350	—
0° F, psi		—	—	—	475	850	—
Properties of Mineral Oil: Viscosity, cSt							
at 40° C	D445	99	99	99	109	109	109
at 100° C		11.2	11.2	11.2	11.6	11.6	11.6

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April 1983

Technical Bulletin
Shell Oil Company

VSI® Circulating Oil

Hydraulic and lubricating oil for rust protection in vapor spaces

Product line

Moisture in the enclosed air spaces over a circulating oil is very likely to cause rusting when it condenses on the cool walls of the case or reservoir. Further, this condensed moisture is constantly replenished as the system "breathes" through vents and other openings. Shell has developed VSI (Vapor Space Inhibiting) Circulating Oil with polar antirust compounds which are oil-soluble and volatile. These corrosion inhibitors fill the vapor space above the oil level to form a rust preventive barrier on the exposed metal surface and combat vapor space rusting. The oils also contain the more customary types of rust inhibiting additives which function below the oil level.

In addition to its ability to combat vapor space rusting, VSI Circulating Oil also has the following important features:

1. Good demulsibility - separates from water readily.
2. Good oxidation stability - over 2000 hour life in the ASTM D 943 Turbine Oil Stability Test.
3. Good resistance to foaming - In the ASTM D 892 Foam Stability Test no reportable foam volume was obtained.

Shell's VSI Circulating Oil is available in the three viscosities most common to hydraulic and lubricating applications. All grades are blended from high quality, high viscosity index, turbine oil base stocks with a unique additive combination to provide good rust protection to internal surfaces of a circulating system whether or not they are completely covered by oil. It is available in 55-gallon drums.

Application recommendations

VSI Circulating Oil is recommended for enclosed lubricating oil systems where rusting is likely to occur. Typical applications include oil-lubricated antifriction bearings and gears, reservoirs, system housings, piping and similar system components. VSI oil is especially recommended for use in machine tools that may be idle for a weekend or longer. Machinery that is idle or in intermittent use is particularly susceptible to rusting as oil drains from interior surfaces. Shell's VSI Circulating Oil can protect such surfaces against rusting.

The properties of VSI Circulating Oil permit run-in of new equipment and rust protection with the same oil by leaving all or a portion of the oil in the machine during shipment, providing that the machine can be sealed. It is not recommended as a protective for surfaces exposed to weather or where the internal surfaces are so well ventilated that inhibitor vapors are prevented from accumulating to an effective concentration.

It is an easy matter to drain the VSI oil from the system and to install the operating lubricant after shipping. In many cases VSI Circulating Oil itself may be left in as the operating lubricant.

The principle of vapor space rusting inhibition.

VSI Circulating Oil protects the surfaces of a lubricating system from rusting by releasing into the air space over the oil a volatile corrosion inhibitor which is then adsorbed on to the surfaces to be protected. The rate of release of the inhibitor and the length of time that an effective concentration is maintained depend on the bulk oil temperature and the degree of ventilation of the system. The balance between temperature and ventilation will determine the rate at which the inhibitor becomes depleted, and therefore the effective antirust life or the oil change period.

Recommended practices for using VSI Circulating Oil

1. High temperature will accelerate inhibitor release while low temperature will retard it. An initial temperature of 80° to 100°F will assist in early distribution of the VSI agents. In an operating system recommended bulk oil temperatures are 80° to 150°F. Temperatures over 150°F should be kept to a minimum and temperatures over 200°F should be avoided because of excessive rust inhibitor loss.
2. A tightly closed system is best, and no attempt should be made to protect a completely open system. Most oil circulating systems and reservoirs afford a relatively closed system to keep the oil free of contamination. Any reduction in system ventilation will help improve the corrosion inhibiting action.
3. The equipment should be clean before installing VSI Circulating Oil. Contamination may promote rusting.
4. Freshly cleaned surfaces should be immediately coated with VSI oil, if possible, to afford protection until rust inhibiting vapors can form.
5. VSI Circulating Oil is designed primarily for protection of ferrous metals. It is non-corrosive to most non-ferrous metals including brass, copper, bronze, zinc, babbitt, aluminum and magnesium. However, contact with lead and lead alloys should be avoided unless the alloys have been tested for suitability under actual operating conditions.
6. For maximum effectiveness, the longest distance from the oil to the surfaces requiring protection should be kept reasonably short. Experience indicates that with 80°F oil the distance should be no more than about six feet. Where temperatures are lower, the maximum distance should be less, and at temperatures over 80°F it may be somewhat greater.
7. Because of the significant effect that temperature and ventilation have on depleting the rust inhibiting additive and because of differences in make-up rates, it is difficult to predict oil service life. However, experience has indicated that while the oil change interval is shorter than that for premium quality turbine oils, it is sufficiently long enough to fit in with plant preventive maintenance schedules.

Examples of field experiences

Some examples of applications that have benefitted from the use of VSI Circulating Oils:

1. VSI oil used to run-in gear drives and to protect finished units during shipping. Units as heavy as 40 tons and as high as 25 feet have been successfully protected.
2. VSI oil used to protect gas and steam turbines. Units are tested with the VSI oil and drained. A residual amount is left in the sump (about 1 inch deep) to replenish inhibitor as needed.
3. VSI oil used to run-in or operate centrifugal air conditioning compressors. Residual oil protects the unit during shipping.
4. VSI oil used to protect gears and bearings of gearhead motors during storage prior to service. Units can range from fractional to as high as 150 horsepower. VSI oil has been left in the unit for up to two years. Before use in service, the unit is flushed and filled with the operating charge. VSI oil could be used for the operating charge if used in the appropriate viscosity.

Typical properties for VSI Circulating Oils

Shell grade number	32	68	100	ASTM
Code number	65249	65251	65254	method
Gravity, °API	31	30	29	D 1298
Flash, COC, °F	395	430	450	D 92
Flash, PMCC, °F	360	360	360	D 92
Pour point, °F	10	10	10	D 97
Neutralization no., TAN-C	0.6	0.6	0.6	D 974
Viscosity, cSt				
at 40°C	31.1	63	94	D 445
at 100°C	5.2	8.1	10.6	D 445
Viscosity index	97	94	95	D 2270
Rust test, synthetic sea water	No rust	No rust	No rust	D 665
Copper corrosion, at 212°F	1A	1A	1A	D 130
Demulsibility, minutes	10	10	10	D 1401
Foam test, stability, ml	0/0/0	0/0/0	0/0/0	D 892
Turbine oil stability test, hrs	2000+	2000+	2000+	D 943
Rotating bomb oxidation test, min	200+	200+	200+	D 2272

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August 1982

REFERENCE # 171

SOURCE : MEQ -1

VT-51

RADIATION RESISTANCE OF 'VITON'

Vulcanizates of VITON fluoroelastomer, irrespective of type or filler, can withstand 10^5-10^6 rads [10^3-10^4 J/kg] with little or no effect on physical properties and 10^6-10^7 rads [10^4-10^5 J/kg] with moderate effect (50% loss of elongation at break, 50% increase in modulus); 10^8 rads [10^6 J/kg] produces a severe effect (final elongation at break <50%).

HANDLING PRECAUTIONS

Using recommended handling procedures, VITON fluoroelastomer polymers and products based on them, in themselves, present no health hazards of which the Du Pont Company is aware. However, certain hazards may arise during the compounding and processing of the raw polymers into finished products. For example, toxic vapors, which may include hydrogen fluoride,[1] may be liberated from products based on VITON during cure, post-cure or service at temperatures above 200°C [393°F]. Adequate ventilation should be provided in work areas where compounds or parts of VITON are being processed or are likely to be exposed to temperatures in this range. Avoid breathing vapors or dusts from such operations. If vapors or dusts are inhaled, remove to fresh air. By following these precautions, there should be no problem in staying within the limits set by OSHA. Before handling or processing VITON, be sure to read and be guided by suggestions in Bulletin VT-100.1, "Handling Precautions for VITON and Related Chemicals".

Compounding ingredients that are used with VITON to prepare finished products may present hazards in handling and use. Before proceeding with any compounding or processing work, consult and follow label directions and handling precautions from suppliers of all ingredients.

[1] Hydrogen fluoride is regulated as an air contaminant in the United States under the Occupational Safety and Health Act (refer to C.F.R. Title 29 1910.1000). This sets the 8-hour time weighted average in any 8-hour work shift of a 40-hour work week at 3 ppm.

SPECIAL NOTE—Except as otherwise provided by law outside the USA, the following information should be noted:

The information set forth herein is furnished free of charge and is based on technical data that Du Pont believes to be reliable. It is intended for use by persons having technical skill, at their own discretion and risk. The handling precaution information contained herein is given with the understanding that those using it will satisfy themselves that their particular conditions of use present no health or safety hazards. Since conditions of product use are outside our control, we make no warranties, express or implied, and assume no liability in connection with any use of this information. Nothing herein is to be taken as a license to operate under or a recommendation to infringe any patents.

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*Reg. U.S. Pat. & TM. Off.

RADIATION RESISTANCE OF "VITON"

The radiation resistance of VITON fluoroelastomer is summarized in the following tables. Before discussing the results, the following guidelines and definitions will be useful:

1. Radiation can be defined as the transmission of high energy waves or particles through space or through a material medium. Energy absorption by the material may produce a variety of effects such as crosslinking and degradation. Excessive energy absorption usually results in failure of the substance, either by embrittlement due to over-crosslinking or by reversion (degradation) due to chain cleavage.

Table I

Comparative Radiation* Resistance of VITON Fluoroelastomers

	1A	1B	1C
COMPOUND			
VITON A	100	–	–
VITON B	–	100	–
VITON A-HV	–	–	100
MT Carbon Black	20	20	20
MAGLITE Y	15	15	15
DIAK No. 1	1	1	1
VULCANIZATE PROPERTIES			
Cure: Press – 30 minutes at 149°C [300°F]			
Oven – step plus 24 hours at 204°C [400°F]			
• Stress-Strain and Hardness at 24°C [75°F]			
Original			
100% Modulus, MPa [psi]	2.6 [375]	2.6 [375]	3.2 [475]
Tensile Strength, MPa [psi]	15.2 [2 200]	15.2 [2 200]	16.8 [2 425]
Elongation at Break, %	320	380	290
Hardness, durometer A	68	69	69
After 5×10^6 Rads (5×10^4 J/kg) Radiation			
100% Modulus, MPa [psi]	4.4 [650]	4.4 [650]	4.8 [700]
Tensile Strength, MPa [psi]	15.4 [2 225]	15.2 [2 200]	15.0 [2 175]
Elongation at Break, %	230	230	220
Hardness, durometer A	71	71	71
After 10^7 Rads (10^5 J/kg) Radiation			
100% Modulus, MPa [psi]	6.0 [875]	5.8 [850]	5.8 [850]
Tensile Strength, MPa [psi]	13.8 [2 000]	13.2 [1 925]	13.2 [1 925]
Elongation at Break, %	170	160	170
Hardness, durometer A	70	72	71
After 2.5×10^7 Rads (2.5×10^5 J/kg) Radiation			
100% Modulus, MPa [psi]	10.4 [1 500]	11.0 [1 600]	9.6 [1 400]
Tensile Strength, MPa [psi]	11.8 [1 700]	12.6 [1 825]	11.2 [1 625]
Elongation at Break, %	110	120	110
Hardness, durometer A	73	78	74
After 5×10^7 Rads (5×10^5 J/kg) Radiation			
Tensile Strength, MPa [psi]	8.6 [1 250]	9.2 [1 325]	9.2 [1 325]
Elongation at Break, %	50	55	60
Hardness, durometer A	78	79	78
After 10^8 Rads (10^6 J/kg) Radiation			
Tensile Strength, MPa [psi]	7.6 [1 100]	7.8 [1 125]	7.4 [1 075]
Elongation at Break, %	10	10	10
Hardness, durometer A	87	87	86

*Dose radiation at room temperature in air in a Van de Graaf Generator

2. *Gamma* radiation may be considered typical of the type to which elastomers would be subjected and is used in many laboratory radiation studies. However, due to equipment availability, test results reported in this bulletin are from exposure to *beta* radiation. Based on these and other tests, evidence indicates that equivalent damage is incurred by equivalent dosages of *beta* and *gamma* radiation under identical environmental conditions.
3. Radiation dose is expressed as rads. One rad is the dose which produces an energy absorption of 100 ergs per gram in one cubic centimeter of air at standard temperature and pressure. 10^6 rads = 1 megarad. Also, one rad = .01 J/kg.
4. In general, radiation doses are additive. A material can be assumed to have a "perfect memory" with regard to radiation exposures. Thus, ten exposures of 10^4 rads [10^2 J/kg] are equivalent to one exposure of 10^5 rads [10^3 J/kg].
5. Concerning elastomer serviceability, a *gamma* radiation dose less than 5×10^6 rads [5×10^4 J/kg] is considered low. Up to 10^8 rads [10^6 J/kg] is considered intermediate and 10^8 to 10^9 rads [10^6-10^7 J/kg] is high.

Data in Table I indicate that the type of VITON polymer has little or no effect on radiation resistance. VITON A-HV and VITON B are identical to VITON A at equal exposures. Table II demonstrates that the use of VITON E-60C, with a variety of fillers, does not improve resistance.

In summary, exposure of vulcanizates of VITON to more than 10^6-10^7 rads [10^4-10^5 J/kg] produces moderate to severe effects on physical properties.

Table II

Test Compounds of VITON E-60C for Radiation[b] Experiments

	2A	2B	2C	2D	2E
COMPOUND					
VITON E-60C	100	100	100	100	100
MAGLITE D	3	3	3	3	3
Calcium Hydroxide	6	6	6	6	6
Fine Ground Calcium Carbonate	–	–	–	30	–
Stearic Fine	–	–	–	–	70
MT Black	–	30	20	–	–
VULCANIZATE PROPERTIES					
Cure: Press—15 minutes at 177°C [350°F]					
Oven—24 hours at 232°C [450°F]					
• Stress-Strain and Hardness at 24°C [75°F]					
Original					
100% Modulus, MPa [psi]	2.0 [300]	6.2 [900]	4.8 [700]	6.6 [950]	6.4 [925]
Tensile Strength, MPa [psi]	7.4 [1 075]	13.0 [1 900]	11.8 [1 700]	15.6 [2 250]	11.2 [1 625]
Elongation at Break, %	200	180	180	190	180
Hardness, durometer A	53	72	66	68	73
After 5×10^8 Rads [5×10^6 J/kg] Radiation					
Tensile Strength, MPa [psi]	5.4 [775]	9.3 [1 350]	9.3 [1 350]	9.3 [1 350]	–
Elongation at Break, %	65	45	60	45	–
Hardness, durometer A	71	85	80	85	–
After 10^9 Rads [10^7 J/kg] Radiation					
Tensile Strength, MPa [psi]	6.2 [900]	9.6 [1 400]	7.6 [1 100]	8.8 [1 275]	–
Elongation at Break, %	45	40	25	20	–
Hardness, durometer A	82	90	88	88	–
After 2.5×10^9 Rads [2.5×10^7 J/kg] Radiation					
Tensile Strength, MPa [psi]	10.8 [1 575]	–	–	6.9 [1 000]	11.9 [1 725]
Elongation at Break, %	15	–	–	<20	<20
Hardness, durometer D	64	77	70	75	76
After 5×10^9 Rads [5×10^7 J/kg] Radiation					
Tensile Strength, MPa [psi]	–	–	–	–	–
Elongation at Break, %	–	–	–	–	–
Hardness, durometer D	80	81	80	85	80

[b] Low Radiation from a U.F. Electron Resonant Transformer

REFERENCE # 172

SOURCE : MEQ-1

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