M·E·M·O

TO: DOMESTIC/EXPORT SALES/WORKSHOP/ENGINEERING LIQUIP DISTRIBUTORS

FROM: DAVID GREGORY

SUBJECT: **TECH TALK NO: 64**

DATE: 11/05/2005

A short Tech Note on manufacturers brochures and data sheets for elastomers in cold climates.

You remember the Shuttle "Challenger" exploding some years ago? It was due to the main Viton o-ring leaking fuel which then ignited. The temp was around -10*C which was defined then as the limit for safe useage in this application at lift-off. Now read the following extracts from brochures....

Gulf rubber....."Service temp range for Viton is -40 to +287*C"
Du Pont........." " " " " " " -30 to +200*C. (Du Pont invented and manufacture Viton).

Then, buried deep in the bowels of a tech book from Du Pont, a statement that the best gauge of USEABILITY of an elastomer at low temp is the TR-10 test (Temperature Retraction) which gives a rating on flexibility.

Du Pont quote a TR 10 rating for Viton of -17*C. Rather different from the general sales brochures quoted above but still higher than the "Challenger" figure.

An obscure Swedish manufacturer's booklet gave the final piece for the puzzle. That is, in low pressure applications (below 1,400 kPa) the above temps must be increased by at least 10*C to compensate for the lack of fluid force to bed the now-hard o-ring in against it's mating surface.

Therefore min temp for use of Viton in our applications is -7*C. {N.B. All data is ref to Viton A. Viton B70 is better but only by a few degrees}.

We need to change to low-swell nitrile (high acrylonitrile) where necessary and possible as the nitrile family have a TR-10 rating of -34*C to -46*C depending on the grade. This translates to a min temp of -24*C in our applications.

Following is a recommended development path.

COLD CLIMATE SPECIFICATION & DEVELOPMENT

Appendices

COLD CLIMATE SPECIFICATION

1 Introduction

Liquip petroleum tanker and terminal equipment has been designed for and used in moderate to hot climates, with extremes of use todate, being UK and France (to -10°C) and Australia and Middle East (to + 60°C).

Company growth must lie in exports with new markets requiring equipment suitable for lower temperatures. Central Europe, Eastern Europe and Korea are examples where temperatures can go below -20°C and we must adjust specifications where necessary to ensure reliable operation.

2 Standard

CEN tanker equipment standards require a temperature range of -20°C to +50°C. It is proposed Liquip adopts -20°C to +60°C to allow for desert operations.

3 Design Factors to be examined

3.1 Elastomers
3.2 Gaskets
3.3 Thermal expansion and contraction
3.4 Ice formation
3.5 Greases and oils
3.6 Plastics
3.7 Fuels with alcohol and MTBE

4 Material Properties

The designer is given some basic properties of currently–used materials in Appendix 1.

5 Tanker Equipment

5.1 VOH700 manhole (as typical example)

5.1.1 Cork gaskets are used in the main 24-bolt flange face and the dip and vapour vent flange mounts. Cork is not recommended for -20°C, our supplier suggests -10°. However I recommend this statement be tested further as no data could be provided to prove it and the original American cars used cork in these temperature conditions.

A simple fix is to change the material to an elastomer but this would cause a significant cost increase.

Longer term, design changes such as incorporating o-ring or washer-style sealing should be examined.

*Recommendation:

Conduct testing on cork gaskets at -20°C for ability to retain sealing under pressure.

5.1.2 Emergency vent seal

Nitrile. OK as is.

5.1.3 Overfill probe holder VOH200-5.

Nitrile. OK as is.

5.1.4 Pressure-Vacuum Vent PVV104U

Currently moulded-on Viton

*Recommendation:

Investigate ability to mould-on high-acrylonitrile (HAN) and change specification after testing.

5.1.5 Emergency Vent design

Emergency vent lid has a deep ‘well’ for the spring location, which is shielded against water entry. If this sealing is damaged, any water forming in the well and subsequently freezing will prevent the vent from opening (but there will be sufficient movement to allow the inspection hatch to open). A possibly more serious effect is if the water enters and ices up the PV vent and prevents the vacuum poppet opening. This could create a vacuum in the compartment.

*Recommendation 1:

Review the design of the water seals on both steel and aluminium bridge versions.

*Recommendation 2:

Review the marketability of a cheaper and simpler Hatch Weather Cover. The concept is not well known, there is less need to access walkways and hatches and it provides excellent benefits. It will be a point of differentiation.

5.2 Vapour Vent AVV075 range.

5.2.1 Piston

Manufactured from acetal and operating in an aluminium housing.

*Recommendation:

Calculate differential in thermal expansion between -20°C and +60°C and compare with current clearance (Note: assume items are machined at +20°C). Consider use of other materials if necessary.

5.2.2 Piston Seal

Currently viton

*Recommendation:

Change to highacrylonitrile (HAN) after check-test.

5.2.3 Poppet seal, outer

Currently Viton

*Recommendation 1:

Change to HAN only after thorough testing.

Note, as HAN expands more than Viton when exposed to petrol it may be necessary to choose an o-ring slightly smaller in overall diameter to give more initial "snap" into the groove. Being a 'loose'seal, it must also be checked against alcohol and MTBE mixed fuels.

*Recommendation 2:

Review the costing of moulded-on HAN to the poppet including the inner shaft seal. A single mould was manufactured many years ago but the piece price was too high. A multiple mould incorporating inner and outer sealing should be re-visited.

5.2.4 Poppet seal, inner

Currently Viton

*Recommendation: change to HAN or see Rec 2 above.

5.3 Internal valve SLV5 & SLV100

5.3.1 Main poppet seal

Currently moulded-on Viton

The SLV5 body is one of our longest running and most reliable products in our range. Change must be approached with care.

*Recommendation: Test several samples of current production for sealing ability at -20°C to establish a need. If required manufacture a batch of HAN poppets and put into local service to prove before entering full production.

5.4 Air actuator "ARO" series

5.4.1 Piston

Manufactured from acetal and operating in an aluminium housing.

*Recommendation:

Re-check thermal expansion differential and clearances. (See 5.2.1 above)

Consider use of other materials if necessary.

5.4.2 Piston seal

Currently Viton

*Recommendation:

Continue testing of HAN seal when available.

Note: refer to test report from MM in email of 7 January 2005. ARO with Viton seal would not actuate the SLV5 below –5°C.

5.4.3 Shaft Seals

Currently

*Recommendation:

Change to HAN after check-testing.

5.4.4 Shaft Bush

Currently acetal

*Recommendation:

Check thermal expansion differential and clearances as in 5.2.1 above.

Carry out test at -20°C to check for any "seizing" due to contraction.

5.4.5 Exhaust port

The exhaust is a sintered metal breather, which could ice up due to damp atmosphere or road spray.

*Recommendation:

(i) Ensure an efficient truck air dryer is fitted.

(ii) Installation instructions to remove the filter and fit a breather tube leading away to exhaust in a sheltered area under the tank through an air filter at outer end. See Appendix 2.

5.5 API Adaptor API450 series

5.5.1 Main poppet seal

Currently Viton

*Recommendation:

Test several samples of current production to -20°C to establish a need. Then only if required, institute a test of HAN seals on local tankers to prove in the field before changing such a critical item.

The extra growth of HAN compared with Viton may necessitate a smaller diameter o-ring to provide more "snap".

Being a 'loose' seal, it must also be checked against alcohol and MTBE mixes – see 5.2.3 above.

5.5.2 Side shaft seals

Currently Viton

*Recommendation:

Change to HAN o-rings after testing.

5.5.3 Side shaft bush

In process of being removed and shaft runs direct in aluminium housing.

*Recommendation:

Test for clearance both -20°C and 60°C.

5.5.4 Sight Glass

Currently acrylic

Acrylic is good at low temperatures but differential thermal expansion is a problem with the current design as is the effect of u-v and mixes of petroleums.

*Recommendation:

Redesign this item at next upgrade. Interim, consider sitting on elastomer gasket to provide expansion 'squash'.

5.6 Diptronic®

5.6.1 Gasket for stick mounting.

Currently cork.

*Recommendation:

Until the testing is completed on cork at low temperatures, supply Teflon gaskets for cold climates such as Finland.

5.6.2 Display on CPU

All LCD displays slowdown at low temperatures and cease to work below -15°C. No damage is caused and the display again operates when warmer and all CPU in formation continues to be processed. A heater cannot be fitted as it violates the intrinsically safe rating. The CPU should be housed where the temperature can be held above -15°C.

5.6.3 Ticket Printer

Ticket printers do not operate below typically o°C and should be housed in a 'warm' area.

6 <u>Terminal Equipment</u>

6.1 Loading Arm Mark 2

6.1.1 Swivel seals.

Both product seal and dust seal are viton o-rings.

There has been no reports of problems and these are critical items therefore any changes must be thoroughly tested prior to productionising.

Recommendation:

(i) Test current production at -20°C with particular attention to low-pressure sealing ability.

(ii) If HAN is necessary, devise a local testing regime for acceptance prior to introduction. Any additional growth in HAN in petrol may lead to increased wear.

6.1.2 Gas Struts

Design of the gas strut is rated for use at -40°C to +100°C.

However Appendix 3 shows the variation in force with temperature. All installations should be designed taking this into account and initial set-up ideally will be in the middle of the range.

6.1.3 Klingerite (or equivalent) gaskets

No change required

6.2 Loading Arm Mk3

6.2.1 Swivel Seals

Product seal is V-style in Viton or Teflon. The Teflon rating is good.

The viton vee-seal is critical and recommendation is as for the Mk2 above.

*Recommendation:

(i) Test current production at -20°C with particular attention low pressure sealing ability.

(ii) If HAN is necessary, devise a local testing regime for acceptance prior to introduction.

6.2.2 Gas struts

As 6.2.1 above

6.2.3 Klingerite gaskets

As 6.1.3 above

6.2.4 Silea Top Load Valve. Rated only -15°C to +65°C.

6.3 API Couplers, API700 and API750

6.3.1 Face Seal

This seal is the critical one, it seals against the API adaptor <u>during</u> loading and works only with the force supplied by the outer poppet spring. This spring force will be reduced by any increased friction in the adaptor poppet due to o-ring increased friction or cold and sticky grease.

In Europe, Arctic and sub-Arctic regions may have exemption from the API standard and instead load with the 3-bayonet (Avery Hardoll) drybreak.

*Recommendation:

Test several production samples of both styles at lowest achievable chamber temperatures to establish what the problems may be.

If possible, take no action as the product is now well established and is selling well.

6.3.2 Internal seals

As 6.3.1

6.3.3 Side shaft bearing and seals

See 6.3.1

7.0 Greases

Greases used for assembly purposes or for packing bearings must be specified to be suitable for the application in terms of minimum temperature, maximum temperature, chemical exposure, bearing load and bearing speed.

All stock Liquip greases specified in equipment are rated to at least –20°C.

Note, however that a purchased pre-packed and sealed bearing used in the electronic register proved to have excessive drag in the northern USA winter.

Any purchased items containing grease should be provided with a detail specification from Engineering.

APPENDIX 1

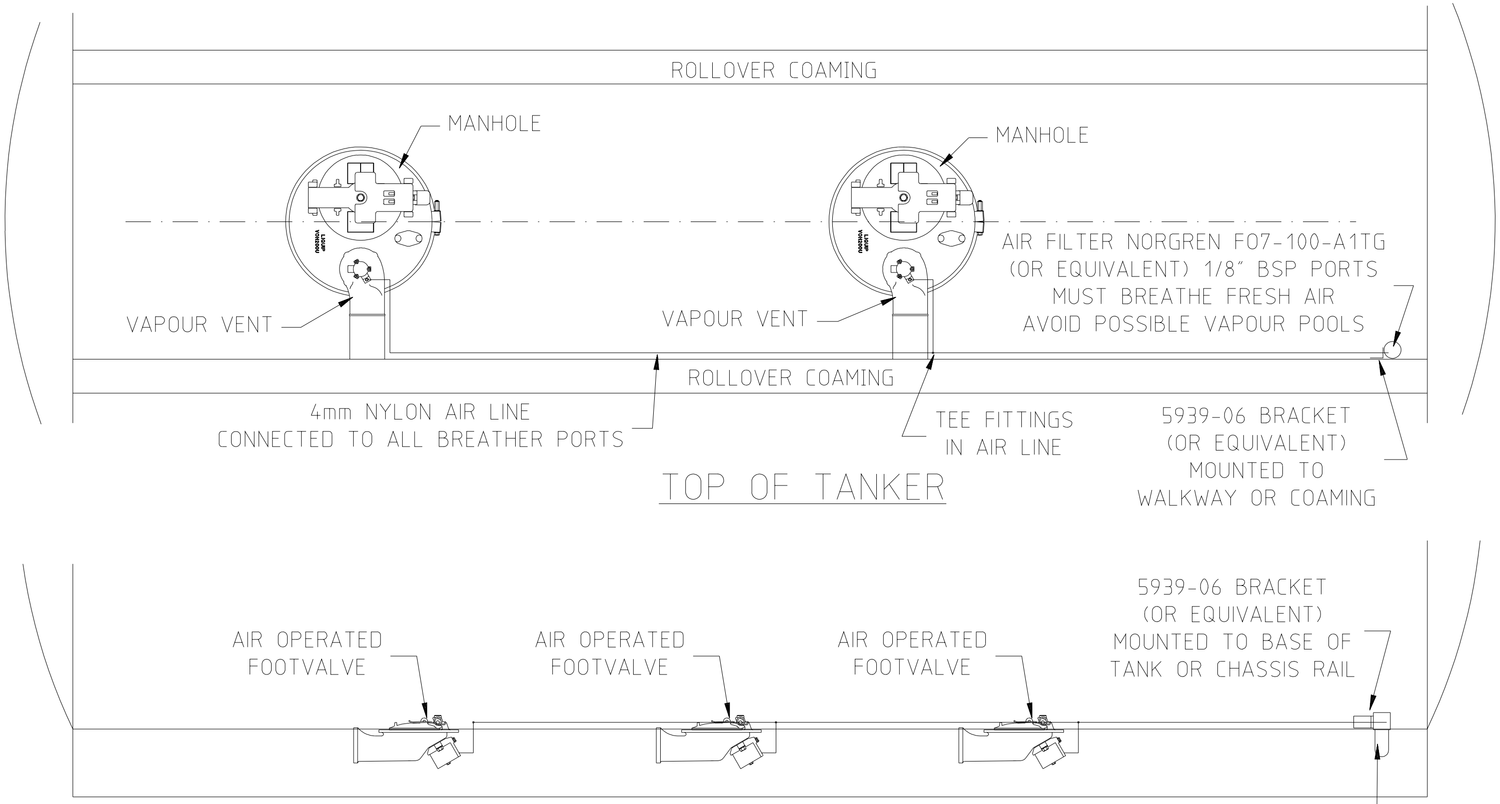
Temperature Data Guide for Materials

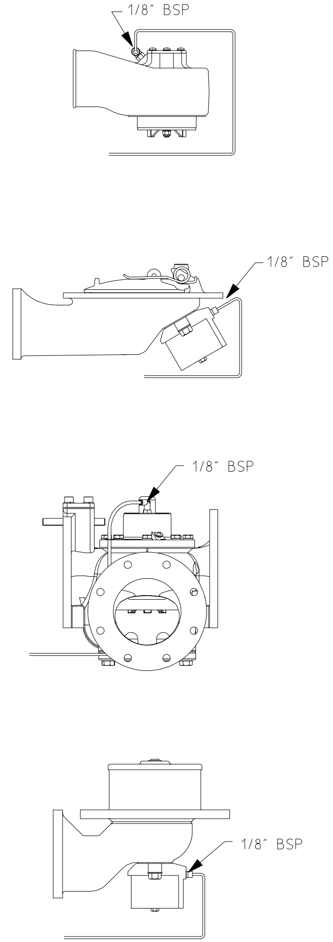
This is generalised data in air only. Check with supplier if more accuracy is required. Exposure to products other than air will change it, and must be tested individually (eg petroleums with extenders such as alcohol or MTBE)

Materials	Linear Coefficient of expansion per °C x 10^{-6}	Minimum useable Temp °C	Maximum useable Temp °C		Comments
			Short Term	Long Term	
Aluminium	24	-40	200	200	
Steel	13	-40	300	300	
Stainless Steel	16	-40	300	300	
Viton A	160	-7	200	150	
Viton B70	160	-10	200	150	
HAN	160	-25	120	95	
EPDM	160	-25	140	120	
Teflon Pure	135	-40	220	180	
Teflon 25% Glass	115	-40	220	180	
Acetal Copolymer	100	-40	150	100	Must be supplied in annealed condition
Acrylic	60	-40	80	70	Must be cast and annealed
Polycarbonate	60	-40	135	120	Must be U-V resistant
Nylon (TYP)	90	-30	150	100	Typical only
Polyurethane (TYP)	130	-40	100	85	Typical only
Polyethylene UHMW	200	-40	80	70	
Epoxy (TYP)	50	-40	150	120	Typical only
Viton Bonded to Aluminium	-	-7	-	110	Results from tests by Macam
Pyrex Glass	3.3	-40	300	200	Thermal shock – delta T up to 250°C

BREATHER LINE EXTENSION FOR AIR OPERATED EQUIPMENT

TO PREVENT THE INGRESS OF FOREIGN OBJECTS, WATER AND POTENTIALLY DAMAGING VAPOURS, ALL AIR OPERATED EQUIPMENT IS RECOMMENDED TO HAVE ITS BREATHER PORT CONNECTED TO AN AIR LINE THAT RUNS ALONG THE LENGTH OF THE TANK AT THE TOP, BOTTOM OR BOTH.
AT THE END OF THIS AIR LINE SHOULD BE A FILTER SUCH AS A PAPER ELEMENT FILTER WHICH SHOULD BE ATTACHED TO THE TANK OR FRAMEWORK TO MINIMISE MOVEMENT.
ALL JUNCTIONS INTO THIS SINGLE AIR LINE SHOULD BE BY PUSH-FIT TEE FITTINGS, AND CONNECTIONS TO THE BREATHER PORTS OF AIR OPERATED EQUIPMENT WILL USUALLY BE BSP SCREWED FITTINGS.
NOTE: ANY EXHAUST PORTS SHOULD BE SHIELDED & PIPED AWAY FROM AIR ACTUATOR





NOTE:
THIS LAYOUT IS NOT TYPICAL OF A TANKER. IT IS MEANT ONLY TO INDICATE AIR OPERATED EQUIPMENT THAT MAY UTILISE A BREATHER LINE EXTENSION.

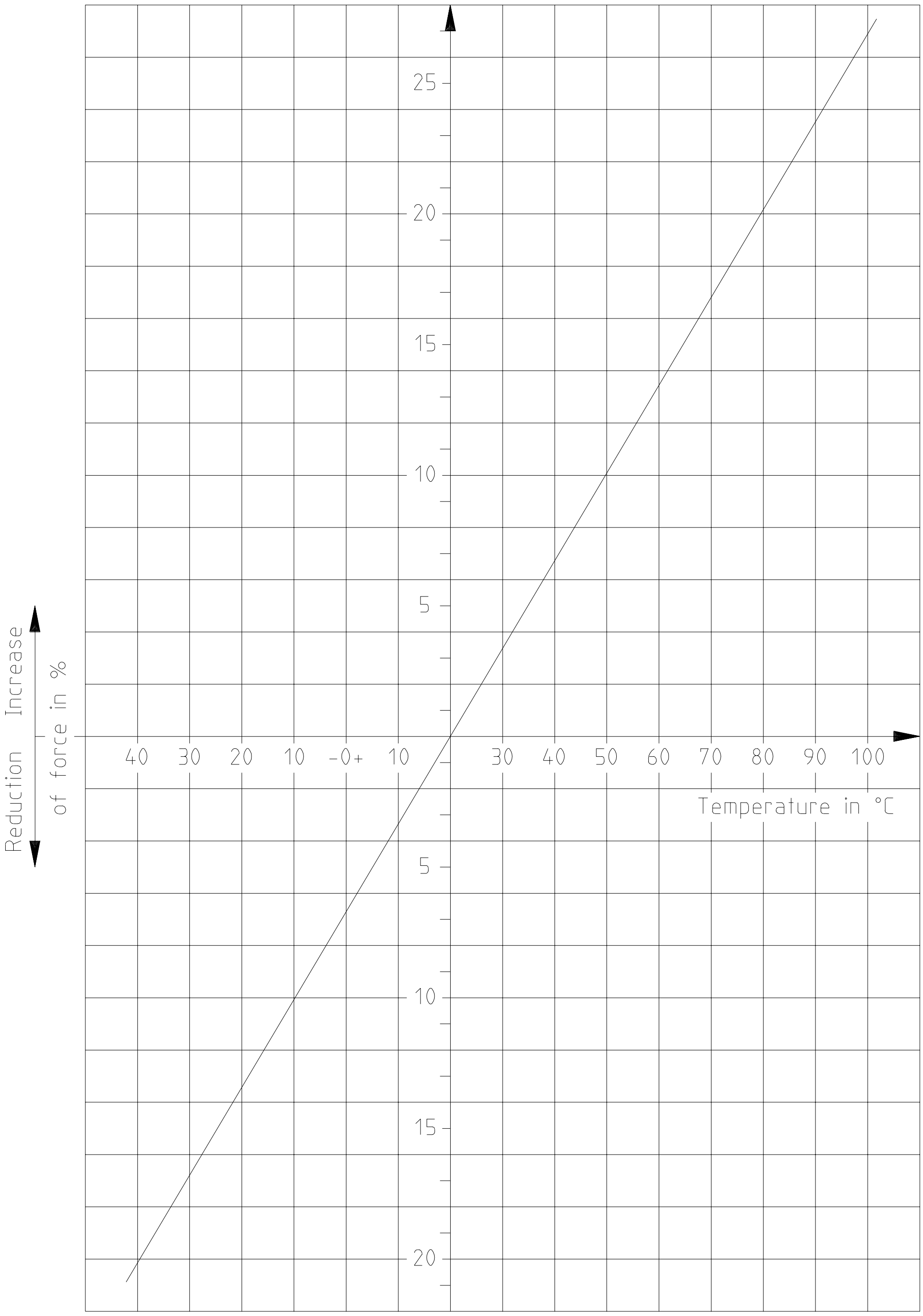
IMPORTANT
Not a certified drawing
Do not use for detail design

P7262
Issue: D

Temperature Response of Gas Spring
Extension Force F1 as a Function of Temperature

- This is an isochor calculation, i.e. precise values for each type of gas spring must be calculated individually.

Permissible operating temperature range
-40°C to +100°C



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Extracted from Stabilus technical datasheet

APPENDIX 4

Summary of Tests to be carried out.

5.1.1 Cork Short spool piece, 100mm and TTMA, welded flanges and end-blanks, at least one face as-cast, BSP fittings both ends, cork gaskets.

Freeze to -20°C for 24 hours

Factory air pressure test.

If leaks, reject cork.

If sealed, repeat but with hydro pump until failure. At room temperature failure occurs at cork gasket at over 1500 kPa typical.

5.1.4 PVV104 and PVV204 series

Moulded poppets.

Manufacture samples in HAN.

Freeze to -20°C for 24 hours.

Test pressure, vacuum and roll-over poppet sealing on normal test rig.

Heat to +60°C for minimum 4 hours, repeat sealing test.

Thermal cycling test eg ice water / boiling water for quick assurance. (These items have been successful in service both in Buna and Viton for over 30 years. It is most unlikely the HAN will differ).

5.2.2 AVV075 Vapour vent

5.2.3 –

5.2.4 Obtain samples of piston seal, poppet outer and poppet inner seals in HAN. (Or moulded poppet if chosen).

Freeze AVV assembly to -20°C for 24 hours. (Preferably 3 samples to enable sequential set-up).

Test minimum air pressure to actuate valve reliably. (Room temp: 250kPa)

Using diesel or similar, pour down spout and check for inner and outer seal leaks.

20,000 cycle test at ambient in fume pit and check wear and post-test leaks.

5.3.1 SLV5-AO and SLV100-AO

5.4.2

5.4.3

5.4.4

Obtain samples of piston seal and shaft seals in HAN.

Freeze SLV5 to -20°C for 24 hours (Preferably 3 samples to enable sequential operation).

Test minimum air pressure to actuate vent reliably (Room temp: 300kPa)

Using diesel or similar, pour down body and check main poppet for leaks.

Air pressure into clamped body and observe for air leaks through shaft and bush out of exhaust port.

20,000 cycle test in fume pit and check for wear and post-test leaks.

5.5.1 API adaptor

5.5.2 -

5.5.3 -

Freeze standard production API 450 (as many as will fit in chamber but minimum of 4) and conduct standard leak and operational tests.

If satisfactory, leave specification as is.

If unsatisfactory, address problem areas as detailed in the sub-sections.

6.1.1 Mark 2 swivel

As API adaptor above

6.2.1 Mark 3 swivel

As API adaptor above

6.3.1 API Couplers

As API adaptor above

APPENDIX 5 (a)

SUMMARY OF DESIGN REVIEWS NEEDED

5.1.5 VOH emergency vent

- (i) water sealing, aluminium bridge
- (ii) water sealing, steel bridge
- (iii) Hatch Weather Cover concept and marketability.

5.2.1 Piston, AVV075

Re-calculate clearances variation with temperature between piston and housing.

5.2.2 Poppet, AVV075

Re-cost moulded-on poppet seals, inner and outer, in multiple mould.

5.4.1 Bush and piston, ARO

5.4.4 Re-calculate clearances variation with temperature between piston and housing.

5.5.4 Sightglass, API450

Re-calculate thermal expansion and contraction and effect on stress.