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**From:** [REDACTED]  
**Sent:** 5/21/2010 8:37:13 PM  
**To:** [REDACTED]; Submissions - Mailbox  
**CC:** [REDACTED]  
**Subject:** Stybarrow Gas Release - MPA 1st Stage Flow Restrictor Valve Failures - 21/04/10 & 11/05/10  
**Attachments:** Stybarrow Venture MPA Comp Excess Flow Valve Leak.pdf; MPA1st Stage flow restrictor Failure Report 21042010 & 11052010.pdf

[REDACTED]

Please find attached the full report for the gas releases that we experienced on the 21<sup>st</sup> April & 11 May.

These failures were due to vibration induced fatigue. We have had vibration analysis performed on both compressors and following that took them out of service to perform some immediate remediation and an extensive program of NDT. We intend to operate with only 1 MP Compressor running at a time under a Case to Operate while we perform remediation on the out of service machine until we are satisfied that we have eliminated all of the excessive vibration.

<<Stybarrow Venture MPA Comp Excess Flow Valve Leak.pdf>> <<MPA1st Stage flow restrictor Failure Report 21042010 & 11052010.pdf>>

Please don't hesitate to get in touch if you require any additional information or would like to discuss further.

Thanks & Regards

[REDACTED]

[REDACTED]

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21th May 2010

Mr Kevin Clary,  
NOPSA OHS Inspector  
National Offshore Petroleum Safety Authority  
Level 22, St Martins Tower, 44 St Georges Terrace  
Perth WA 6001

Dear Kevin,

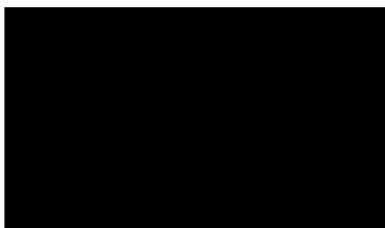
**RE: STYBARROW VENTURE: MPA Compressor 1st Stage Flow Restrictor Valve Failures – 21<sup>st</sup> April & 11<sup>th</sup> May**

Please find attached the investigation report and associated actions following the failure of a Flow Restrictor Valve on MP Compressor A on the 21<sup>st</sup> April and a similar repeat failure of the replacement valve on the 11<sup>th</sup> May. These failures were found to be vibration induced fatigue exacerbated by the weight and rigidity of the tubing take-off above the fitting, coupled with over tightening on installation. This arrangement has now been replaced by a flexible connection on all similar take-offs on both Compressors while a permanent solution is engineered.

MP Compressor A remains out of service while we implement a program of remediation. Our MP Compressors are currently under a Case to Operate which stipulates various actions to be taken to address this situation and also limits the run hours on each machine while vibration remains high. Additional vibration analysis will be performed after each program of remediation so that we can be confident that we have addressed the issues.

If you require any further details or clarification on the information submitted please let me know.

Yours Sincerely



## STYBARROW VENTURE: FLOW RESTRICTOR VALVE LEAKS

Event #'s: AOAEV10040014 & AOAEV10050002

Brief Description: Repeat gas releases from MPA Compressor 1st Stage Suction instrument tapping for SIS PIT-0301A-06.

Occurred Dates: 21-Apr-2010 01:15 WST & 11-May-2010 03:02 WST

Event Types: Environmental

Potential Consequence Severities: Level 3

Actual Consequence Severities: Level 1

Environmental Overall Risk Rankings: Level 3

Involved Environment Name: Air

Severity: No lasting effect

Investigator Role: Stybarrow OIM

Equipment: Flow Restrictor Valve (FRV) at the piping interface instrument tapping for Pressure Transmitter SIS PIT-0301A-06, ie same location for both events, although for the 2nd event – the flow restrictor that leaked had been relocated post 1st event from the nearby instrument tapping for PIC PIT-0301A-05.

Normal operating pressure: 8.4 barg for both events

Regulator (NOPSA) informed of incident. This report represents the more detailed report required by sections 20 and 21 of the Regulatory Incident Investigation Forms

### INCIDENT DESCRIPTIONS:

In both incidents the running MPA Compressor tripped on low low pressure in the 1st Stage Suction as read by field SIS Pressure Transmitter PIT-0301A-06. The cause of the low low pressure signal to the transmitter was sudden fracture of the threaded inlet section of the 414 bar (6000 psi) rated flow restrictor valve (FRV), which therefore created the reported gas releases. Soon after tripping, the MPA compressor package was blowdown in a controlled manner, and then isolated and Nitrogen purged to prevent further leakage. It was estimated for both events that 22kg of gas escaped to atmosphere from the fractured flow restrictor valves.

The fractured FRVs were inspected, and in both cases found to have fractured right through the inlet threaded section.

### BACKGROUND

The Stybarrow Gas Compressor hydrocarbon instrument tubing was upgraded in 2009 under an approved Engineering Change Request (ECR) and Scope of Work. The upgrade included the addition of tubing OEM



standard FRVs to join the instrument tubing to the process piping take-offs. The process piping take-offs are flanged ANSI rated Monoflanges that provide double block & bleed valving, and a reliable interface between instrument tubing and process piping. The upgraded design is then based on the FRVs acting as flow shut-off switches that automatically close when a flow spike occurs – eg from a tubing failure – thus preventing and limiting an uncontrolled release of gas.

The FRVs specified and installed in 2009 were the NACE certified Hoke make XVH Series with NPT threaded connections for the inlet and outlet ports. These threaded FRVs valves are commonly used in the offshore hydrocarbon industry and are key elements of standard instrument tubing hook-ups for FPSO's such as Griffin Venture, Pyrenees Venture for other Operators such as Woodside. These FRVs are pressure rated for 414 bar (6000 psi), and the wall thickness in the fracture zone is 6 mm plus the NPT thread form.

In addition to the Excess Flow valve upgrade, new, heavy wall instrument tube was installed with new support brackets and tubing loops / spirals (of approximately 2 turns around) to provide a more flexible tubing section free of any compression fittings (ie locations of most previous failures where the tube is thinned through the compression fitting ferrules). Tube loops are a common industry practice to separate vibrating machinery or vibrating piping supported sections of tube from joining tube sections that are mounted to nearby, but differentially moving / vibrating, structures such as structural steel columns or instrument stands.

#### FAILURE ROOT CAUSE

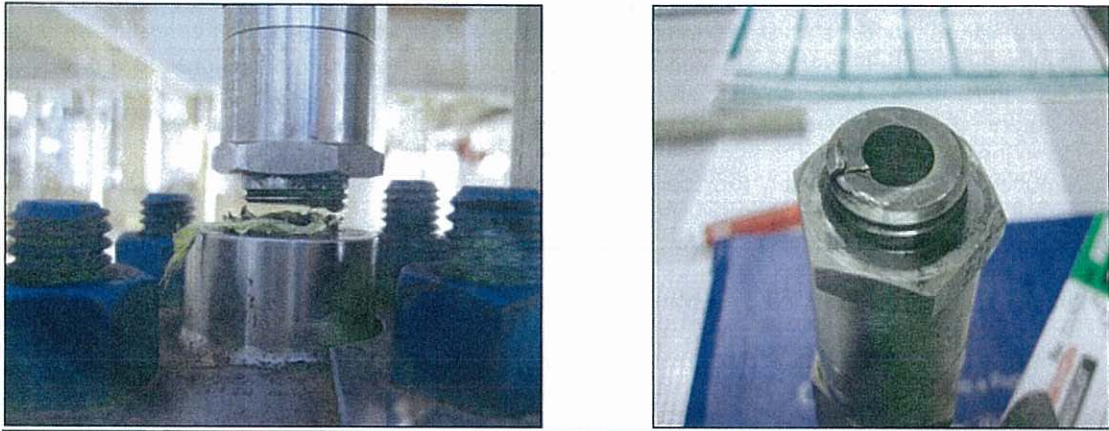
The failure root cause has been confirmed as vibration induced mechanical fatigue which was accelerated by over-tightening of the FRV NPT thread.

From the vibration surveys completed the vibration of the 1st Stage Suction piping is high, and the change to FRVs with heavy wall tubing loops in 2009 has exacerbated the prevailing high vibration of the small bore FRV & tubing when compared to the new build instrument hook-up arrangement. Lab reports and removal of all other FRVs has confirmed that these threaded valves were over-tightened – overtightening creates a high residual stress in the threaded component that reduces its fatigue life and therefore accelerates fatigue failure.

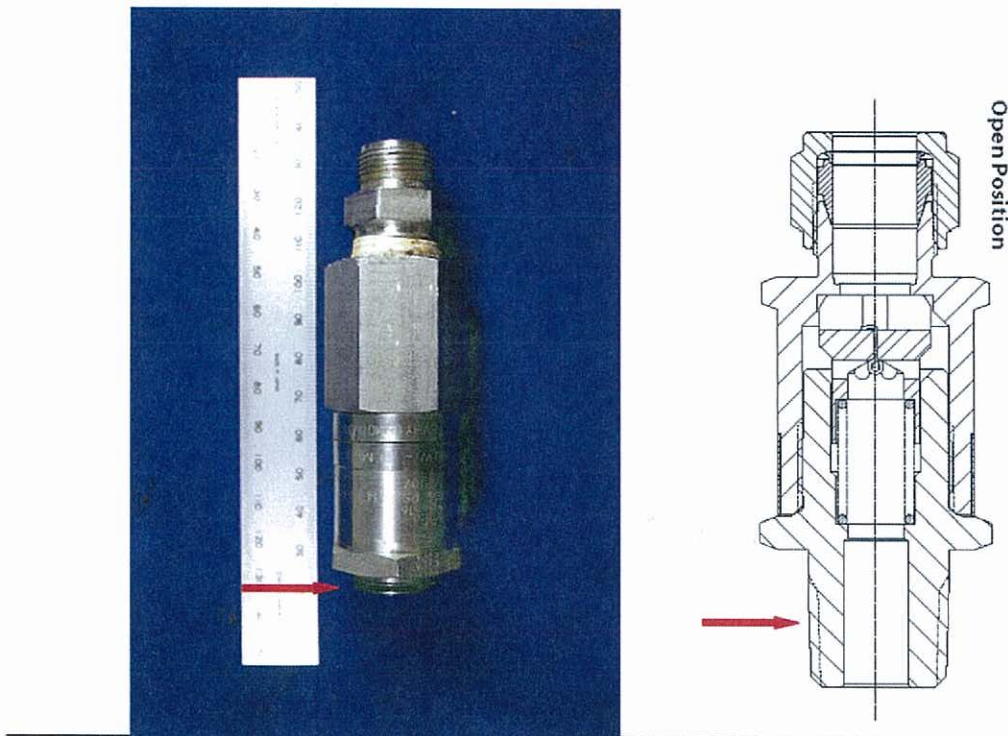
Figures 1 & 2 Pre-event Piping and Instrument Tubing arrangement at MPA 1st Stage Suction



Figures 3 & 4 Close-up of Failed Flow Restrictor Valve



Figures 5 Failed Flow Restrictor Main Body & 6 Flow Restrictor Cross Sectional Drawing



ACTIONS TAKEN TO RETURN TO SERVICE:

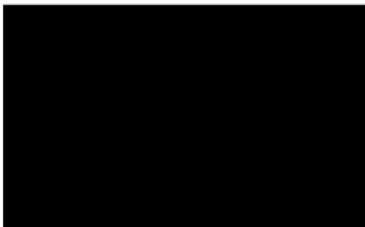
- (1) Case To Operate (CTO) raised, approved and issued to control operation of both MP Compressors whilst high vibration is reported. This includes formal risk assessment, review and approval from Offshore and Onshore Management teams, review cycle control, change management control and governance for all short and medium term changes offshore as per this list of actions and the CTO. Vibration analysis will be repeated at each stage of remediation and while it is outwith acceptable operating limits run hours will be limited accordingly.



- (2) All Flow Restrictor valves have been removed and either replaced with new ones (enough spares for one compressor only), or NDT performed to assure integrity of any that are to be temporarily re-used. Installing Technician's have been re-advised of the correct tightening method for NPT threaded connections.
- (3) Detailed NDT (DPI & MPI to check for any indication of surface fatigue failure & radiography to provide assurance of weld quality) completed on all vulnerable small bore piping branches, and specifically on the monoflange that housed the flow restrictor valve - no defects were detected
- (4) All tubing pigtails temporarily replaced with flexible hose connections under an approved Temporary ECR prior to returning compressors to service
- (5) Detailed check of all piping and volume bottle supports completed – some were loose and have be re-tightened
- (6) Access restricted around running compressors
- (7) Increased personnel awareness of the risks of gas releases from the compressors and all offshore work tasks reviewed daily to minimise exposure of personnel to the compressor modules
- (8) Detailed inspection & verification of all piping and volume bottle orifice plates against original design – there are at least 4 orifice plates per compressor stage
- (9) Preliminary vibration analysis on the compressors, structures, large and small bore piping, flow restrictor valves and tubing has been performed and key issues have been addressed (ie as per this list).

#### ACTIONS GOING FORWARD

- (1) Detailed vibration analysis on the compressors, structures, large and small bore piping, flow restrictor valves and tubing to be conducted and action plan implemented
- (2) Further engineering study & investigation into the piping & small bore vibration and pulsation issues to be undertaken to provide the long term remediation actions to minimise the likelihood of leakage in the future
- (3) Project phase pulsation study to be reviewed and a revised study performed to capture all as built structural and piping information



21/5/10