



PGS OptoSeis™ System Focus on Reliability





FMECA Directly Impact Test Program

- FMECA used to focus test program

Consequence Likelihood	Impact				Increasing Likelihood				
	Safety & Health	Reputation	Environment	Assets	1	2	3	4	5
	Acute Injuries & Community Health	Damage to industry reputation	Physical and Biological	Facility Damage, Business Interruption, Loss of Product	Rare or unheard of	Has occurred once or twice within industry	Reasonable to expect that the event will not occur at this facility.	Has occurred several times in the industry. Exceptional conditions may allow consequences to occur within the facility lifetime.	Has occurred once or more at this facility. Conditions may allow consequences to occur at the facility during its lifetime.
1 Incidental	Workforce: Minor first-aid injury to a single person in the workforce. Treatment is minimal or not necessary. AND Public: No impact.	Slight impact: customer awareness but resolution within PGS	Impact such as localized or short-term effects on habitat, species, and environmental media.	Minimal damage, negligible downtime or asset loss. Costs < \$ 30,000.	L (2)	L (3)	L (4)	L (13)	M (5)
2 Minor	Workforce: One or more injuries not serious. Full recovery with medical treatment. OR Public: One or more first-aid injury. Treatment is minimal or not necessary.	Limited impact: resolution involves active participation by technical personnel	Impact such as localized, long-term degradation of sensitive habitat or widespread short-term impacts to habitat, species or environmental media.	Some asset loss, damage and/or downtime. Costs \$ 30,000 to \$ 100,000.	L (5)	L (14)	L (20)	M (2)	
3 Moderate	Workforce: One or more serious injuries. Full recovery with extensive medical treatment. OR Public: One or more injuries, not serious. Full recovery with medical treatment.	Considerable impact: negative awareness and active involvement by asset and high level technical personnel	Impact such as localized but irreversible, widespread and persistent changes in habitat, species or environmental media.	Serious asset loss, damage to facility and/or downtime. Costs of \$ 100,000 to \$ 1 Million.	L (11)	L (22)	M (6)	M (9)	
4 Major	Workforce: Full-time (1+) OR Public: One or more serious injuries. Full recovery with extensive medical treatment.	Extensive negative attention with specific customer, high level PGS and customer awareness and involvement	Impact such as significant widespread and persistent changes in habitat, species or environmental media (e.g. widespread habitat degradation)	Major asset loss, damage to facility and/or downtime. Costs of \$ 1 Million to \$ 35 Million.	L (4)	M (10)	M (12)	H (8)	H (1)
5 Severe	Workforce: Multiple fatalities (5-50) OR Public: Multiple fatalities (1-10)	Extensive negative attention in the industry	Impact such as persistent reduction in ecosystem functions or a widespread economic impact. Costs > \$ 35 Million.	Severe asset loss or damage to facility, significant downtime with approximate economic impact. Costs > \$ 35 Million.	M (1)	M (5)	H (1)		



8. Qualification Testing

- 8.1 Failure in Time (FIT) Testing
- 8.2 Cross-Axis Isolation
- 8.3 Cross-Axis Isolation Analysis
- 8.4 Acoustic Sensitivity
- 8.5 Acceleration Sensitivity and Bandwidth
- 8.6 Sensitivity Versus Temperature and Depth
- 8.7 Sensitivity Loss
- 8.8 Sensitivity Loss and Variation
- 8.9 Returned Optical Power Analysis
- 8.10 Pressure Life (Hydrophone and Accel Housing)
- 8.11 Pressure Life (Cable)
- 8.12 Accelerated Aging
- 8.13 Drop Shock
- 8.14 Vibration
- 8.15 Survival Temperature
- 8.16 Thermal Shock
- 8.17 Survival Depth
- 8.18 Reeling
- 8.19 Section Noise Floor
- 8.20 Hydrophone and Accelerometer Stress Aging Analysis

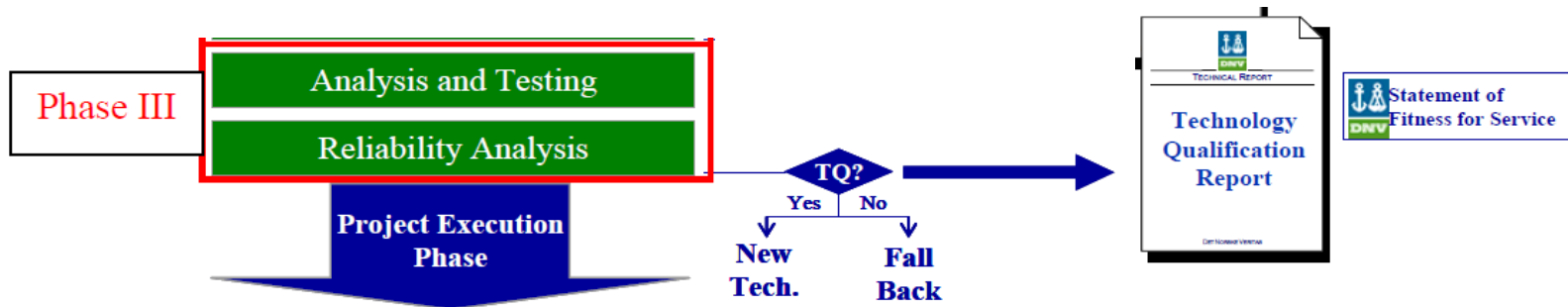
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DNV – Qualification Process

Phase III

- One more phase to go: **Phase III !**



Critical Target Milestones in Phase III (highlighted by DNV)

- Failure in Time (FIT) Tests for Fiber Optic Components
- Life Testing of Elastomer Materials for Seawater Use
- Deep Water Hydrophone Accelerated Life Test
- Reliability Prediction of a Redundant Bidirectional Sensing System



DNV – Design Verification Tests (DVT) Status

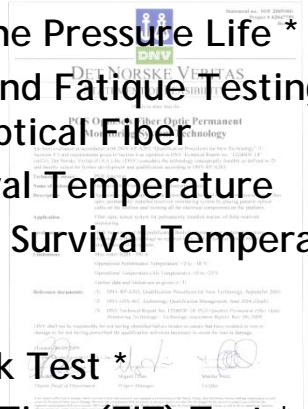
Completed

Ongoing/Planned

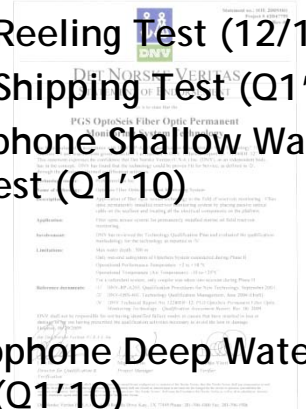


Shallow Water

- Hydrophone Pressure Life *
- Strength and Fatigue Testing on OFS-AT-SMF Optical Fiber
- Pad Survival Temperature
- Connector Survival Temperature

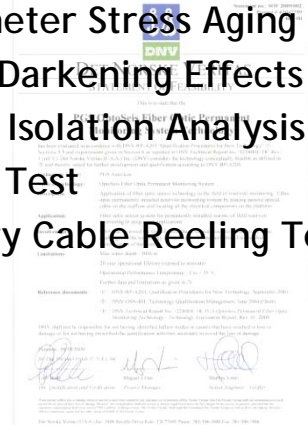


- Cable Reeling Test (12/17) *
- Cable Shipping Test (Q1'10)
- Hydrophone Shallow Water Accelerated Life Test (Q1'10)

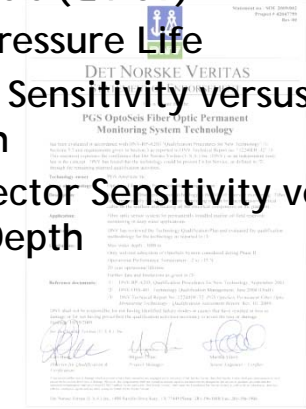


Deep Water

- Drop Shock Test *
- Failure in Time (FIT) Test *
- Life Testing of Elastomer Materials *
- Accelerometer Stress Aging Test *
- Hydrogen Darkening Effects Analysis
- Cross-Axis Isolation Analysis
- AFL Cable Test
- Preliminary Cable Reeling Test



- Hydrophone Deep Water Accelerated Life Test (Q1'10)
- Carbon Coated Fiber Lifetime Reliability Analysis (Q4'09)
- Pad Pressure Life
- Cable Sensitivity versus Temperature and Depth
- Connector Sensitivity versus Temperature and Depth



* Witnessed by DNV



OPTOSEIS Reliability Program

- **Our system reliability is based on tests not hypothetical**
- **Cable**
 - Tubes have been tested to twice anticipated operational pressure
 - Testing has shown that long lengths of tube are required to prove survivability adequately
- **Hydrophone**
 - Tests to prove hydrophone life involve elevating pressure to project life (multiple high pressures and measure days to failure to project)
 - Subject to elevated temperature to age materials and then test to operating conditions
- **Accelerated aging via temperature (Arrhenius reaction rate theory) and then test for performance**
 - Materials (aging in seawater)
 - Optical components (temperature and humidity based are Belcore procedures)
 - Assemblies
- **System reliability calculations based on actual tested values, not vendor supplied or industry standard values**



OptoSeis Summary

- **PGS provides backing of strong seismic company**
- **PGS partners to provide total solution including installation, data gathering & data processing**
- **Once technology shown to yield good seismic data focus shifted to prove and improve reliability**
 - **Partnered with DNV to certify the OptoSeis System to RP-A203**
 - **Affect of partnering with DNV was to add a significant pool of experts to our team**
 - **DNV certification work demonstrates PGS commitment to reliability of OptoSeis**
- **PGS and its manufacturing partners offer low cost reliable solution.**
- **PGS personnel is a combination of experts with fiber sensor experience dating back to mid 80's along with young enthusiastic minds**