



Cryolinks for Advanced Virgo

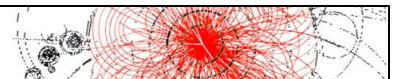
Quality assurance procedure

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Abstract:

The current Virgo vacuum level needs to be improved by about a factor of hundred in order to be compliant with the required Advanced Virgo sensitivity. Such an improvement requires baking out the interferometer arms. To separate these arms from the towers that hold the mirrors and allow the bake-out, four cryogenic vacuum links will be installed. This note describes the quality assurance plan for the realization of these cryolinks.

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HISTORY OF CHANGES

Rev. No.	Date	Pages	Description of changes
A	05-05-2011	All	Initial version

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1. INTRODUCTION

The Virgo project is a physics experiment for detection of gravitational waves. The enhancement of the Virgo sensitivity by a factor 10 requires an improvement of the present vacuum level. This will lower the phase noise for YAG light scattering from the residual gas inside the 3 km long interferometer (ITF) arms. The present system operates at about 10^{-7} mbar (dominated by water) although it has been designed and tested to reach a base pressure below 10^{-9} mbar (dominated by hydrogen) after an overall bake out.


The residual pressure in the ITF arms has to be reduced by a factor of 100 to reach an enhancement in sensitivity by a factor of 10. By means of cryogenic links the migration of water from unbaked towers to the ITF arms can be stopped and a base pressure below 10^{-9} mbar can be reached.

Cryolinks will be installed between the mirror towers and the existing DN1000 valves of the Virgo experiment. The vacuum vessels of the cryolinks will have different lengths (links at the end-towers are 6000 mm long, and at the input-tower 5400 mm). Aspired are four identical cold vessels in the cryolinks, since the optical design is not completed at this point, it may be that the dimensions of the prototype will slightly deviate from that of the other links.

2. SCOPE

This document provides a description of the quality assurance measures taken in the production of the cryolinks for Advanced Virgo. The document has been realized through discussion with Demaco, a company with expertise in cryogenic systems.

3. QUALITY ASSURANCE FOR CRYOLINK

QUALITY PLAN  J.F.J. van den Brand M. Doets K. de Roo		Specifications: - AD 2000 Merkblatt - PED 97/23/EC - - -	References: - Project no.: P100331 - Project name.: Virgo Experiment - Customer ref.: 00043376 - Revision: 01 - Date: 110323	Legend: - H = hold point ► notify inspector ► stop - W = witness point ► notify inspector ► continue - R = review point ► continue ► check afterwards - - -				
Remarks:								
No.	Subject	Requirement	Criteria	Extent	DeMaCo	Inspection	Customer	Remarks
1.00	INITIAL INSPECTION							
1.01	Design examination	AD 2000	AD 2000	Drawings	H	PE		Detail design only
1.02	Mech. stress calculations	AD 2000	AD 2000	Proces parts	H	PE		Detail design only
1.03	Risk analysys	PED	Project specific RA	Cat. I - IV	H	PE		
1.04	Material application	AD 2000	AD 2000	Proces parts	H	PE		
1.05	Welding document review	ISO 15614-1 EN 287-1	AD 2000	PQR, WPS, WPS	H	QC		
2.00	MATERIALS							
2.01	Traceability	PED	PED	DeMaco class 1				
2.02	Material certificates	EN 10204	Type 3.1	Proces parts	R	QC		For each heat
2.03	Welded proces pipes	EN 10217-7 DIN 17457 PK1						1.4301/ 1.4306/ 1.4307 (304(L))
2.04	Welded vacuum pipes	EN 10217-7 DIN 17457 PK1						1.4301/ 1.4306/ 1.4307 (304(L))
2.05	Machined parts/sheet metal parts outer vessel							1.4301/ 1.4306/ 1.4307 (304(L))
2.06	Machined parts/sheet metal parts inner vessel							AW5754
2.05	SS Fittings	ISO 5251						
2.06	Bellows	DIN 17440	1000 cycles at 100% stroke					Calc. acc. EJMA latest revision

No.	Subject	Requirement	Criteria	Extent	DeMaCo	Inspection	Customer	Remarks
2.07	Tees	EN 10253-3 (Piping) EN 10253-4 (vessel) DIN 2615						
2.08	Elbows	EN 10253-3 (Piping) EN 10253-4 (vessel) DIN 2605						
2.09	Reducers	DIN 2616						
2.10	Filler materials	EN 12072 (RVS) EN 18273 (AL)						
3.00	MANUFACTURING							
3.01	Cleaning	P100331 project specific cleaning specs	Vacuum Clean	All parts				
3.02	Welding	AD 2000	WPS	Proces welds				
3.03	Multi layer insulation	DEN-22	25 layers	Proces parts				
3.04	Evacuation	Project specific document	<5*10 ⁻⁶ mbar piping <1*10 ⁻⁹ mbar vessel					Pumps supplied by customer
3.05	Bake Out of outer vessel	P100331 project specific Bake-Out specs	1 wk at 400 C					
3.06	Pickling & passivation	PR-07	No discolouring	Outside welds				
3.07	Packing & marking	DEN-25		All spools				Closure on all openings
4.00	TESTING & INSPECTION							
4.01	Visual weld inspection	EN 970	ISO 5817-B	All welds	R	OC		
4.02	Longitudinal weld test (vessel)	AD 2000	AD 2000 HP5/2	AD HP5/2 Extend	R	OC		Cat II Vessel
4.03	He leaktest meth. 1	P100331 Project specific based on DEN-30	<1*10 ⁻¹⁰ mbar.l/s	Critical welds, Flexibles/ bellows, Critical parts				
4.04	Radiographic test (piping)	EN 1435-B	AD 2000 HP5/3	10% of butt welds	R	OC		On proces butt welds of SEP piping
4.05	Radiographic test (vessel)	EN 1435-B	AD 2000 HP5/3	2 x main vessel circumferential weld	R	OC		Cat II Vessel
4.06	Pressure test (piping)	AD 2000 HP512R	DEN-31	100%	H	OC		PL=1,43* (Ps+1) barr(g)

No.	Subject	Requirement	Criteria	Extent	DeMaCo	Inspection	Customer	Remarks
4.07	Pressure test (vessel)	AD 2000 HP30	DEN-31	100%	H	OC		Pt= 1.43*(Ps+1) bar(g)
4.08	Valve function test	DEN-06	<1*10 ⁻⁴ mbar.l/s	Valves				
4.09	Cold functional test		Functional testing	Cryo equipment				Test of Inner Vessel
4.10	He leaktest meth. 2	P100331 Project specific based on DEN-30	<1*10 ⁻¹⁰ mbar.l/s	All spools				
4.11	Vacuum retention test	DEN-33	<2*10 ⁻⁴ mbar	All spools				After 24 h
4.12	Cleanliness	P100331 Project Specific Cleanliness inspection	UHV clean	VIRGO Vessels				Nikhef vacuum clean procedure
4.13	Dye Penetrant Testing	EN 571-1	EN 1289-1	10% of socket welds	H	OC		
5.00	FINAL INSPECTION							
5.01	Documentation	PED	PED	User manuals	R	OC		
5.02	Declaration of Conformity	PED	PED	Cat. I - IV	R	OC		
5.03	CE-marking	PED	PED	Cat. I - IV	H	OC		
5.04	Databook	Customer	Order confirmation		R	OC		Including check Safety Valve Setting
6.00	FAT							
6.01	Factory acceptance test	Customer	Project specs	Inspection points	H	OC	H	Cold shock/function test (6.02) Helium leak test (6.03) Vacuum level check (6.04) Spectrum Analysis (6.05)
6.02	Cold shock test Function test	DEN-32; DEN-06	No condens or cold spots on the outside	2 hours with LN ₂				Check of valves and instruments during Cold Shock Test
6.03	He leaktest meth. 3	P100331 Project specific based on DEN-30	<1*10 ⁻¹⁰ mbar.l/s	Inner Vessel				Combined with 6.02 during cold shock test
6.04	Vacuum level check	P100331 Project Specific	<1*10 ⁻⁹ mbar	Inner Vessel Outer Vessel				Dynamic vacuum
6.05	Residue Check using Mass spectrum analyser	P100331 Project Specific	<1*10 ⁻⁹ mbar	Inner Vessel Outer Vessel				Check for residue during 6.04