

**Minutes of the Waste Heat Recovery Units and Exhaust Systems Meeting**

**Edinburgh, 23rd of April 2009**

**Present:**

Alberto Traverso	University of Genoa
Roald Skorping	Statoil Hydro
Ole E. Torp	Mjørud
Colin Bailey	Dresser-Rand
Herwart Hoenen	RWTH Aachen
André Mom	VGT
Mohsen Assadi	University of Stavanger
Abdulnaser Sayma	University of Sussex
Chris Lappee	Nuon
Mikael Sävinger	Camfil Farr Power Systems
Gary Lock	Frazer-Nash Consultancy
Pål Kloster	Kanfa-Tec
Bernard Quoix	Total
Francisco Zamora	ETN

**Absent but with interest:**

Berthold Noll	DLR
Michel Delanaye	Cenaero
Kees Meijer	Stork Thermeq

**1. Welcome and introduction**

R. Skorping started the meeting by thanking all the participants for their presence and gave a short description of the project. Subsequently, the participants introduced themselves and gave a brief explanation of their role and position. A copy of the document “Design Standard for Gas Turbine Exhaust System and Waste heat Recovery Unit” was delivered to all participants. This document (which is attached at the final part of these minutes) will be used as a base for the project. It is important to note that what is presented in this document is by no means final, aspects such as the nature of the project, its title, particular objectives and overall management of the project are yet to be decided.

**2. WHRU and Exhaust System Manufacturers Presentation**

**Kanfa-Tec**

P. Kloster started his presentation by giving some information on Kanfa-Tec and their products, such as WHRUs, heat recovery steam generators, and exhaust silencers. He mentioned that some of the issues that they have observed in exhaust systems are:

- Vibration and leakages at the Bundle support.
- Cracks in transitions, casing, ducts and stacks.
- Bellow problems in turbulent areas.



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P. Kloster mentioned that they are currently working to solve these problems with aid of CFD, FEM, vibration analysis and an improved Bundle support system. However, he recognises the need of improvement in both the WHRU and Exhaust System and welcomes the project initiative.

### Mjørud

O. Torp presented some information on the WHRU's and exhaust systems that they manufacture. He mentioned that the design of these equipments has been historically based on: low prices, low weights and assuming uniform flow. Hence, some other aspects that haven't been taken care of and should be are:

- Choice of materials
- Actual loads
- Fatigue
- Interfaces
- CFD, FEM, Acoustic, Flow and FSI Analyses.

O. Torp mentioned that the products should include adapted inspection programs and ought to be based on individual design basis. Finally, he welcomed the initiative to start this project and thanked ETN for the invitation to the workshop.

### 3. Discussion and Commitments

It was confirmed that all the participants at the meeting are interested in the subject and are committed to take part in the development of the project. A. Mom stated that VGT will not participate actively in the project but that they will provide some contacts of other companies which could be interested in it. On this respect, B. Quoix mentioned that he will contact Shell to look for their participation and ETN will contact BP and Neste oil.

The discussion then shifted to the short-term and long-term objectives of the project, as well as its coverage. It was decided that the project should focus mainly on WHRUs for offshore applications on its first stage and perhaps later it could cover Heat Recovery Steam Generators used in the electricity industry.

In order to identify and decide on the overall and particular objectives of the project the participants agreed to schedule a one-and-a-half day meeting in June at a venue to be confirmed in Brussels. At this meeting, it will also be discussed if the final objective of the project is to produce an "ETN/Industry Standard" or a "Best Practice Guide Line" for the design and manufacture of WHRUs and Exhaust Systems. To conclude, R. Skorpning mentioned that a design review of previous WHRUs should be included as an activity of the working group. Finally, he thanked all the participants and finalised the meeting.

### Actions

Item	Responsible	Deadline
Schedule initial meeting	F. Zamora	15 <sup>th</sup> May
Agenda for initial meeting	R. Skorpning, F. Zamora	15 <sup>th</sup> May
Contact Shell	B. Quoix	15 <sup>th</sup> May
Contact BP and Neste Oil	F. Zamora, C. Bjorkqvist	15 <sup>th</sup> May



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## Appendix 1

### Design Standard for Gas Turbine Exhaust System and Waste Heat Recovery Unit

Waste heat recovery is a subject that, although not new, has gained a lot of attention over the last few years. A better utilisation of the heat produced from the combustion of fuel in Gas Turbines (GT), can be directly translated into better overall efficiencies and economical savings for the operators.

Waste heat recovery units (WHRUs) are heat exchangers utilised to recover heat from a hot gas stream. In the case of GT cycles, these units are used for two main purposes:

- In the power generation industry, to produce steam which can be used to drive a steam turbine or for other type of processes.
- In the oil and gas industry, for heating medium applications, typically glycol solutions, hot oil or water.

In order to enjoy the benefits of using gas turbine cycles that make use of a waste heat recovery unit, operators rely on the optimum performance of the WHRU itself and the exhaust system. However, experience has shown that the performance of these two elements is not entirely satisfactory. **The equipment requires maintenance after only a few years of operation, which causes unscheduled shutdowns and loss of oil or gas production.** Hence, not fulfilling the criteria stipulated in the API Standard 616, section 4.1:

“The equipment (including auxiliaries) covered by this standard shall be designed and constructed for a minimum service life of 20 years and at least 3 years of uninterrupted operation.”<sup>1</sup>

The Norwegian oil company StatoilHydro has recognised this problem and brought it forward to the European Turbine Network’s (ETN) table in order to address it. Being a user orientated association, ETN has studied the feasibility of this subject and has decided to develop this document in order to capture the reasoning to initiate a project on this matter.

#### Objective

It is important to mention that the overall objective of this project is to **develop an ETN standard for the design of gas turbine exhaust systems and waste heat recovery units.**

In order to build up a standard of high quality, ETN is looking for the participation of different stakeholders involved in the research, design, manufacture, maintenance and operation of WHRUs and exhaust systems.



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Roadmap

# European Turbine Network A.I.S.B.L.

To achieve the main objective of this project, the following steps have been proposed:



## Step I. Collection of experience data from gas turbine operators

Gas turbine operators face different problems and failures (issues) in the GT exhaust and WHRU's. It is proposed that these issues are to be prioritised. Therefore, a number of them have been listed. However, it is important to underline that this list is not exhaustive.

To carry out the prioritisation of the different issues, a ranking system has been proposed:

- 1 if the user is **very interested** in addressing the issue.
- 2 if the user is **interested** in addressing the issue.
- 3 if the user is **not interested** in addressing the issue.

The proposed issues, together with a format to prioritise them are shown below:

Company Name		
Issue Number	Issue	Mark
1	Cracks in the exhaust channel	
2	Loss of insulation in the exhaust channel	
3	Power loss due to turbulent flow	
4	Leaks in expansion bellows	
5	Leaks in flanged joints	
6	Leaks in weather gasket	
7	High vibrations on the WHRU	
8	Poor silencer performance	
9	Problem with bypass control of the WHRU	
10	Others (Please specify)	

It is envisaged, that with the results of this prioritisation, the particular objectives of the project can be established. Furthermore, this would be a powerful tool to subdivide the work load between the interested stakeholders.

Once the prioritisation and the determination of particular objectives have been concluded, the collection of data from the gas turbine operators can be carried out either by a postgraduate student or a member of the ETN staff.

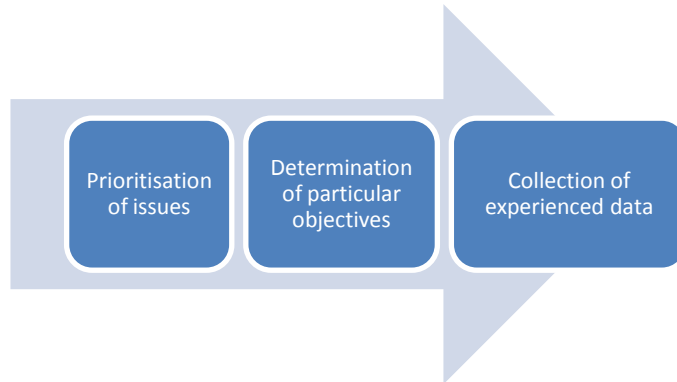
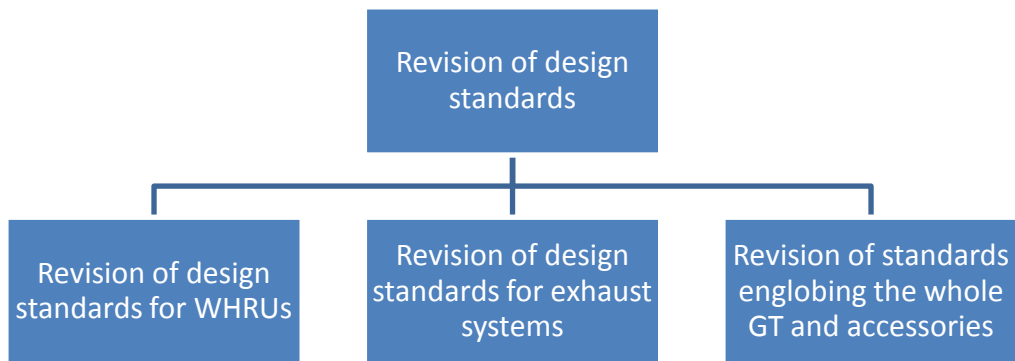
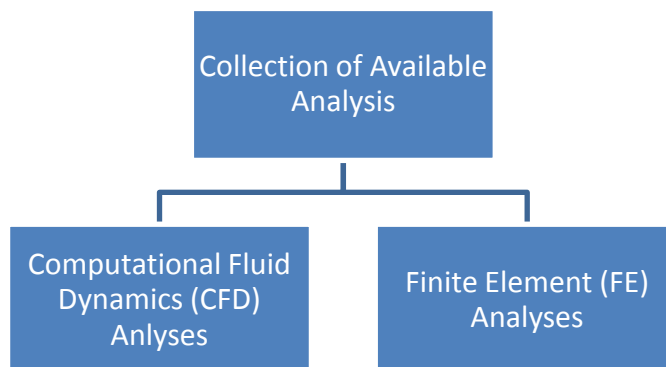


Figure 1 Evolution of Step I

**Step II. Revision of existing WHRU and Exhaust System design standards**



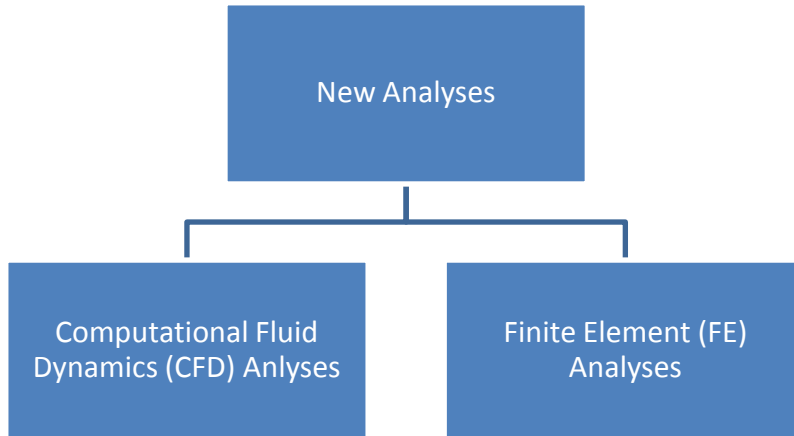
**Step III. Collection of Available CFD and FE Analysis**



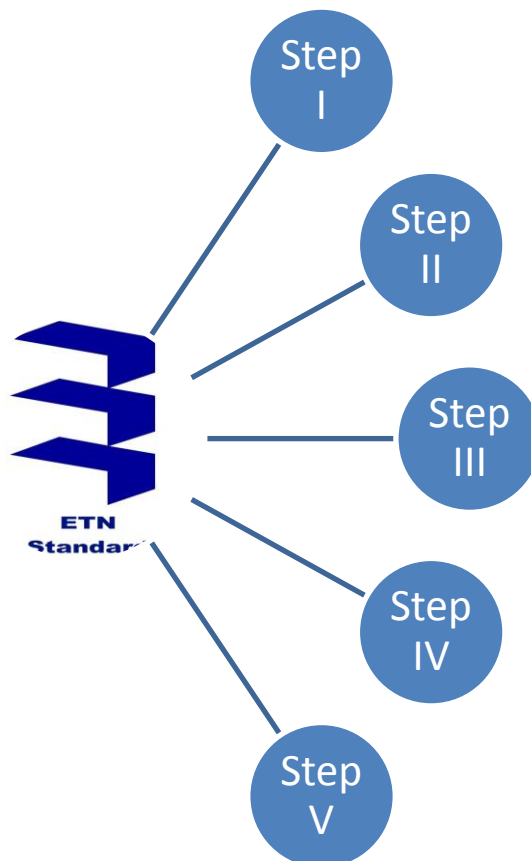


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Step IV. Execution of new CFD and FE analyses



Step V. Development of ETN Standard





### References and Bibliography

1. - American Petroleum Institute. Gas Turbines for the Petroleum, Chemical and Gas Industry Services. API standard, 616. Washington, D.C.: American Petroleum Institute, 1998.
2. - Raju, K. Nagabhusan. Industrial Energy Conservation Techniques: (Concepts, Applications and Case Studies). New Delhi: Atlantic Publishers and Distributors, 2007.
3. – Skorpning, Roald. Design standard for gas turbine exhaust system and waste heat recovery unit (WHRU). European Turbine Network, 2009.
- 4.- Boyce, Meherwan P. Gas Turbine Engineering Handbook. Gas Turbine Engineering Handbook. Boston [u.a.]: Gulf Professional Publ, 2006.