Minutes of Exhaust Systems Project Group Meeting

11 October 2011, BIHL Offices, Burgess Hill, UK

Attendees:

Dave Carroll	AAF
Evert Verdouw	Aarding Thermal Acoustics
Dingo Kist	Aarding Thermal Acoustics
Herwart Hoenen	RWTH Aachen
Pascal Decoussemaeker	Alstom
David Champneys	BIHL
Liam Hewitt	Frazer-Nash
Graham Hawkes	Frazer-Nash
Pål Kloster	Kanfa-Tec
Terje Kaspersen	Kanfa-Tec
Ole Torp	Mjørud
Paul Setchfield	Mjørud
Havard Kristiansen	Mjørud
Alex Winterburn	Oxensis
Amélie Pesquet	Total
Claude Prébénde	Total
Sjirk van de Goot	VBR Turbine Partners
Karen Geris	ETN

1. Summary of previous meetings

During the ETN Workshop in March 2011 it was decided to relaunch the exhaust system project group (PG), and to divide the activities in two areas: the operational approach and the theoretical approach.

During the meeting in June 2011, in Paris, the participants shared and discussed operational feedback. The outcome of the meeting was the merging of the existing standards and the accompanying datasheet. Each PG member was to review a section of the standard to establish a first draft of an ETN standard.

At the teleconference (29 September 2011), PG members discussed the issue of the boundary conditions that were needed to be defined for the reliable design of an exhaust system. The discussion was to be continued during the meeting on 11 October in Brighton.

2. Summary of the meeting on 11 October 2011 in Brighton

The focus of the meeting in Brighton was to discuss the progress of the work performed since the Paris meeting (June 2011) and to discuss the advantages of the theoretical approach and the required boundary condition data in exhaust system design.

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- The first part of the meeting was based on the minutes of the teleconference of 29 September and an update of the merged standard.

- The second part of the meeting included the following presentations:

  - Design of Exhaust Systems based on user cases – Theoretical Design and Testing, presented by Ole Torp, Mjørud
  - Structural Design Methods for Exhaust Duct Systems – the application possibilities of CFD, presented by Liam Hewitt and Graham Hawkes, Frazer-Nash
  - Instrumentation Possibilities of Exhaust Systems, presented by Alex Winterburn, Oxsensis
  - Application of CFD for Flow Analysis of Exhaust Systems, presented by Herwart Hönen, RWTH Aachen

- The last part of this meeting was dedicated to defining the steps to come to be able to plan the year to come for the evolution of this standard.

3. Update on the progress of the merged standard

The process of the review of the standard was discussed and the following structure agreed upon;

1. The review-partners of each section to comment on the existing standard
2. The review-partners of each section to agree on a draft to be uploaded on the WIKI or send to Karen and Amélie for integration into the overall standard
3. All organisations review the entire standard

The progress of the update of the merged standard is as follows:

Section	Member	Update	Date
Instrumentation, control	Alstom, Mjørud	Done and comments from both companies integrated	Closed
Ducting (including sealing, expansion joint), silencer	Aarding and AAF	Bilateral contact to review and write their section	Last week of January 2012
Dampers	Mjørud, Camfil Farr	Mjørud to send to Camfil Farr for review	Last week of January 2012
Insulation and liners	Frazer-Nash, Camfil Farr, BIHL	Frazer-Nash will forward their section, including Kanfa-Tec's comments, for review by BIH. Once reviewed they will forward it to Camfil Farr.	Last week of January 2012
Tubes,fins, tube supports	Mjørud, BIH	Kanfa-Tec has already reviewed this section. Mjørud and BIH to bilaterally review the section.	Last week of January 2012
Manufacturing	Statoil, Aarding	Bilateral contact to review and write their section	Last week of January 2012
Installation, commissioning	Total, Kanfa-Tec	Total will review this section and forward it to Kanfa-Tec and Statoil. It was highlighted that end user aremore aware of this issue than exhaust system designers.	Last week of January 2012

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4. The theoretical design approach and the necessary tests

a. Design of Exhaust Systems based on user cases – Theoretical Design and Testing - Ole Torp, Mjørud

The velocity map initially presented was only provided for one operational condition, without taking into account the back-pressure of the exhaust stack and it didn't illustrate the turbulence of the flow.

The last model shown in the presentation was validated with on-site measurements on units to establish an adequate model of the exhaust stack and to validate the CFD model. The model illustrated the pulsation linked to the turbine exhaust flow of which the frequency corresponded to the first mode of the duct (low frequency around 18-20Hz). The same level of modeling illustrated the impact on the vibration of the unit for partial opening of the dampers in the case of a WHRU.

Kanfa-Tec commented that one of the criteria to avoid the **excitation between the duct and the exhaust flow** would be to design the system so that the first mode is above a given value. Fraser-Nash specified that the excitation isn't the only problem resulting from vibration but also fatigue of the exhaust due to additional stress. Kanfa-Tec asked if other frequencies above 30Hz had ever been noticed in exhaust systems. Aarding responded that in some cases a 40Hz mode was noted and which implied the need of reinforcement of the structure. Mjørud commented that the problem also resulted from the general arrangement of the design (stacking and bents within the exhaust system).

The impact of the partial load of the turbine, the bleed valve (typically sonic jet into the exhaust), and the thermal changes (yield of the material) were also listed as important factors that influence the design of the exhaust system.

Kanfa-Tec also questioned if any one experienced the case where the simulation showed problems within the design but in operation where operating without any issue? Mjørud had indeed experienced this but according to them it would just be a matter of time before the problems would appear. An alternative cause could be the fact that the initial condition may not have been exact in the modeling. Aarding also commented that the **operational conditions** could be **different than** the ones established for the **design phase.**

BIHL commented that the problem of the boundary limits between the exhaust stack and the turbine OEM supply is still an issue; the point of including the diffuser in the turbine's OEM scope was noted.

b. Structural Design Methods for Exhaust Duct Systems, the Application Possibilities of CFD – Liam Hewitt and Graham Hawkes, Frazer-Nash

It was presented that the incoming flow data and the geometry of the exhaust are **essential boundary conditions** for correct modeling. **Reliability of the estimated lifetime** of the expectancy of the unit increases with adequate modeling according to the design case.

Total commented that the modeling seemed to mostly concern the ducts and not the tubes and bundle section. Frazer-Nash responded that the same type of modeling could be applied to the tube section as well. The group agreed that for WHRU applications most of the issues are with the ducting whereas with HRSG applications most of the issues are with the tubes.

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c. Instrumentation Possibilities of Exhaust Systems – Alex Winterburn, Oxsensis

This presentation highlighted the **different types of instrumentation** that can be used on exhaust systems for test measurements and for operational purposes (unmanned platforms).

It included new types of instrumentation such as piezo-resistive pressure probes that would allow static and dynamic pressure measurements in high ambient temperature environment (>1000°C) and therefore would allow measurements within the exhaust gas path.

5. Tools and limits to define and establish an adequate model

a. Existing Modeling Tools and Configuration – Herwart Hönen, RWTH Aachen

The presentation highlighted the importance of the correct application of CFD through a case study where the wrong CFD modeling didn't identify the problem of the exhaust system. The calculation region has to include the gas turbine exit in order to be able to consider the regarding flow and geometry conditions. Correct modeling should include the following: code validation, recommendations on modeling, boundary conditions, validation, grid setup and resolution, etc.

It was as previous that for **accurate CFD simulation** one should know the **exhaust flow field at the GT outlet** and the **geometry of the exhaust diffuser.** It was noted that this data would probably be very difficult to obtain from GT OEM's since it would be modeling a part of the turbine OEM's scope of supply. The group agreed that the reason that Alstom received the exhaust flow field is that the end user was aware of the benefits of having the data and thus included it in the information to be received from the GT OEM when purchasing the GT. It was therefore decided that the **importance of CFD simulation should be highlighted** in the standard. Frazer-Nash suggested including a decision tree in the standard which the purchaser could use to determine the time and the cost that would be associated with a certain desired level of CFD modeling. BIHL insisted that the standard should specify that the decision of the required CFD level is a purchaser requirement.

The group agreed that the best way to validate the CFD code is to use a benchmark case in the appendix of the standard. RTWH AACHEN stated that Dresser-Rand offered to perform some testing at their facilities if it would not interfere with their own testing. TOTAL would see if test could also be done during the string testing of a new unit.

Frazer-Nash agreed to take the lead on the CFD issue. They offered to write a work plan, including the expected costs and a time frame for the validation case, with the help of RTWH AACHEN

HRSG – WHRU Separate Standard Issue

During the September teleconference it was suggested to write a separate standard for the design of the HRSG and WHRU as using one common standard could lead to confusion. Moreover, there is already an API recommendation on the design of HRSG. During the meeting in Brighton it was decided that the group will first focus on the **creation of a standard for WHRU systems** and later **amend the API HRSG standard** through recommendations. The WHRU standard should have a similar structure as the HRSG API standard.

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6. Project Timeline

2012	**First Quarter**	Finalize draft of each section of the WHRU standard and datasheet
	Second Quarter– First Meeting	- First review of entire HRSG standard - Review of HRSG API 534 using WHRU standard - Presentation work plan (required budget and description of work) of test for CFD benchmark - Presentation of the redaction of the ETN standard to become ISO/API standard
	Third Quarter – Fourth Quarter	- Perform test for CFD benchmark
	Second Meeting - Fourth Quarter	- Last review of the WHRU standard - Last review of the HRSG API 534 amendments - Presentation of the CFD benchmark case
2013		- Reformat the standard to fit ISO/API requirements

7. Chairmanship

Ole Torp (Mjørud) agreed to become co-chairman of the project group for the upcoming year.

8. Upcoming Actions

Review of the sections of the standard and the datasheet should continue as stated above with the addition of Frazer-Nash and RWTH Aachen who will define the “mechanical and thermal design” of the standard.

Action Owner	Description	Deadline date
TOTAL/ETN	Prepare and send the minutes of meeting	Wk 45 – Beginning of Nov 2011
ALL PRESENTERS	Send their presentations to Amélie and Karen	Wk 45 – Beginning of Nov 2011
ETN	Upload the presentations and MoM on the Wiki	Wk 45 – Beginning of Nov 2011
MJORUD	Review the merged requirement to be provided by supplier from the conference call	Wk 45 – Beginning of Nov 2011
TOTAL	Provide string test estimated possibilities for 2012	Wk 45 – Beginning of Nov 2011
ETN	Organize conference call last week of January for update	Wk 45 – Beginning of Nov 2011
ETN	Check with the different PG members availability for next meeting and location (offer from Statoil to host in Bergen)	Wk 45 – Beginning of Nov 2011
ALL members	Review their assigned section of the standard*	End of Jan 2012
ALL members	Review their assigned section of the datasheet*	End of Jan 2012

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ETN	Integrate this merged requirement into the merged standard as bullet point items in the corresponding sections	End of Jan 2012
TOTAL/ETN	Merge sections rewritten and sent out for global review	15 Feb 2012
ALSTOM	Review the standard with the API recommendation on HRSG	End of March 2012
ETN	Provide an estimate to have the standard formatted into ISO/API requirements.	End of March 2012
RWTH AACHEN , FRASER-NASH	Estimate the budget, the requirements, and the time frame for the benchmark case at the Dresser-Rand test facilities or with Total string test possibilities.	End of March 2012

(*) for the review of the standard and the datasheet it was specified it's better to provide them in a separate document and send it back to Amélie and Karen so it can be compiled.

9. Next Meetings

A conference call should take place in the last week of January to report on actions and progress of the review of the merged standard. The time and date of this teleconference will be communicated in November.

For the following meeting it was suggested to have the meeting in conjunction with ETN's AGM however RWTH AACHEN suggested to hold the meeting in the beginning of April to avoid being away from the office for an entire week. Statoil offered to host the meeting. Based on discussions with Statoil, 2 potential dates will be proposed. The agenda of the meeting will consist of the discussion of the review of the entire standard and the work plan and budget related to CFD benchmark case.

Amélie closed the meeting by thanking BIH for hosting the meeting and all the participants for their contribution.

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