



**International Flame Research Foundation**

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**American Flame  
Research Committee**

**2010 Pacific Rim  
Combustion Symposium**

Sept. 26-29th  
Maui, Hawaii

## **IFRF status, research and services**

Jacques Dugué  
*IFRF Vice President*

LeoTognotti  
*IFRF Director*  
Livorno, Italy



# Summary

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- IFRF organization
  - ◆ Mission
  - ◆ Members
  - ◆ Industrial sectors
  - ◆ Experimental facilities
  
- Services provided by the IFRF
  - ◆ On-line library
  - ◆ Conferences and TOTeMs
  - ◆ Industrial combustion Journal
  - ◆ Electronic handbook
  - ◆ Training and education
  
- Networking and research activities at IFRF
  - ◆ EFRI
  - ◆ Members Research Programme



# IFRF Mission

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- Mission set by original statutes:
  - ◆ the attainment of knowledge and experience bearing upon combustion in an efficient and environmentally acceptable manner;
  - ◆ to accumulate this knowledge within an international centre of excellence;
  - ◆ to place this knowledge at the disposition of others for further development and industrial application.
- A “not for profit” Foundation
- Managed by its Members’ representatives



# IFRF Research : a brief history since 1948

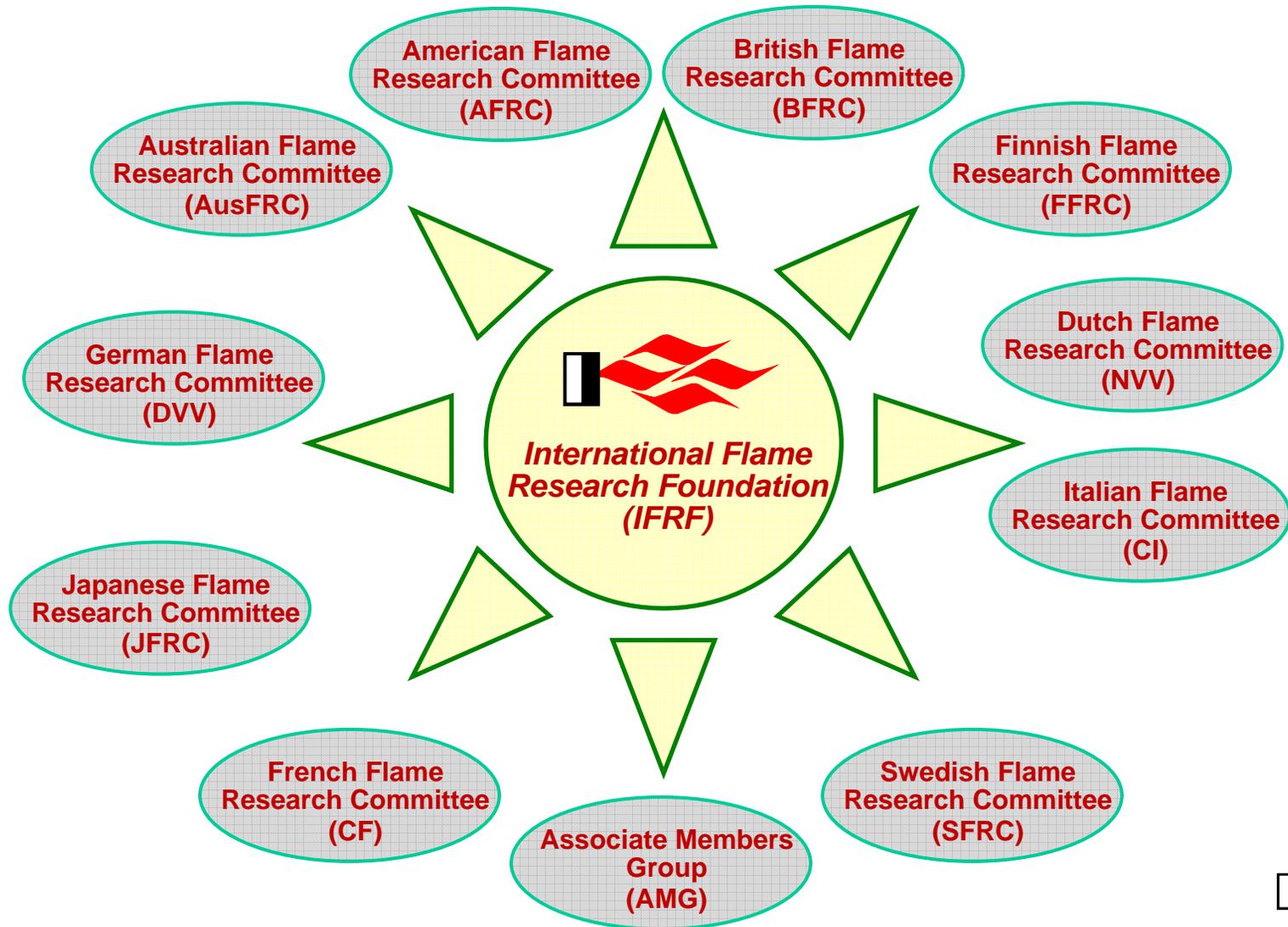
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- Basic understanding
  - ◆ In-flame measurement techniques – semi and industrial scale (1950s)
  - ◆ Flame aerodynamics (1960s)
  - ◆ Computer models (1970s 1980s 1990s 2000s)
- Thermal efficiency
  - ◆ Enhanced flame radiation and heat transfer (1950s)
- Environment
  - ◆ NOx reduction – semi-industrial scale demonstrations (1970s to 2000s)
  - ◆ Flameless combustion, oxyfuel combustion (1990s, 2000s)
- Energy
  - ◆ “Energy crisis” – fuel flexibility (1980s)
  - ◆ Solid fuels char. database (coals, biofuels and wastes) (1990s, 2000s)
- Carbon
  - ◆ Combustion without nitrogen – carbon sequestration (2000s)



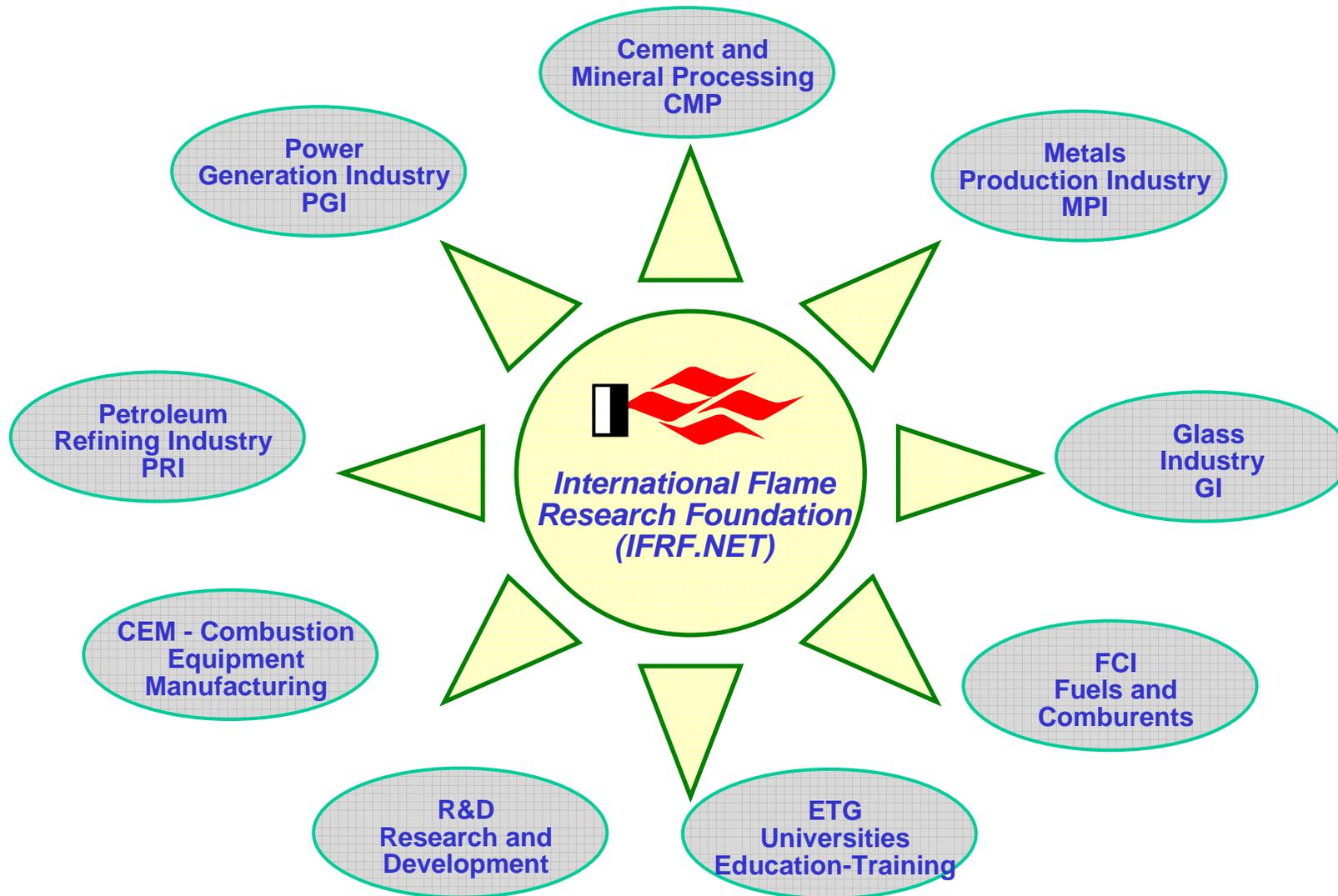
# 130 IFRF member organizations from Industry and Academia

network of around 1500 people in 23 countries

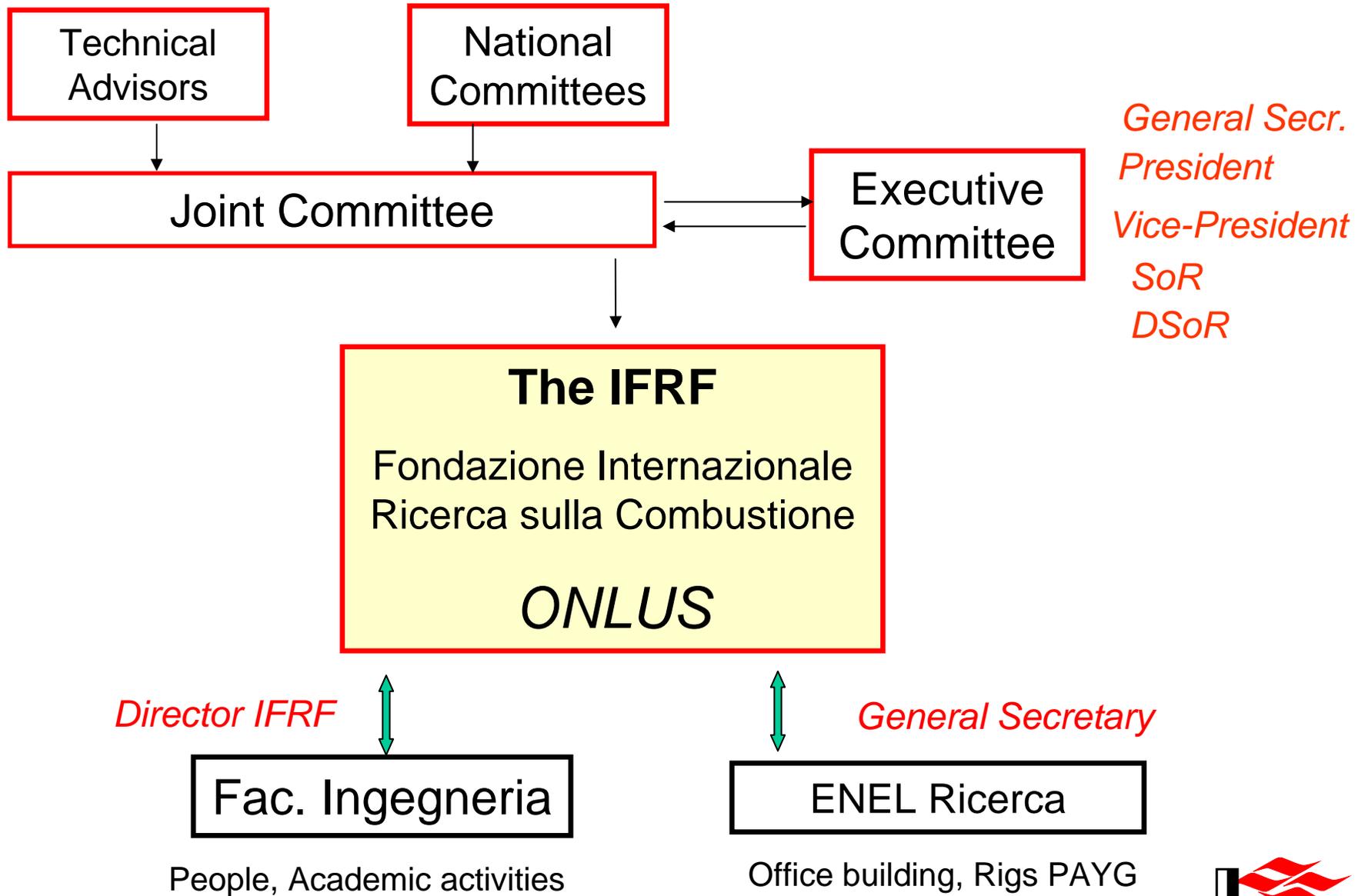


# The IFRF : Represents all sectors of industrial combustion

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# The IFRF : New Structure since 2007



# IFRF Officers - Executive Committee

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- President: **Dr. Richard Waibel** John Zink Co., USA
- Vice President: **Mr. Jacques Dugué**, TOTAL, France
- General Secretary: **Dr. Sauro Pasini**, ENEL Ricerca, Pisa, Italy
- Superint. of Research: **Prof. Neil Fricker**, Glamorgan University, UK
- JC Representative: **Dr. Susumo Mochida**, Nippon Furnace Co., Japan



# IFRF Officers - Joint Committee members

*A members: National Committees representatives*

- **Philip Smith** AFRC (USA)
- **Roger Dudill** BFRC (UK)
- **Willi Nastoll** CF (France)
- **Giuseppe Girardi** CI (Italy) - *new*
- **Frank Sowa** DVV (Germany)
- **Pasi Miikkulainen** FFRC (Finland)- *new*
- **Susumu Mochida** JFRC (Japan)
- **Jochem Groot** NVV (Nederland)
- **Truls Liliedahl** SFRC (Sweden)

*B Members: technical advisors*

- **Klaus Hein,** Stuttgart University, Germany
- **Christian Mueller** Clyde Bergemann, Germany
- **Tsuneaki Nakamura** Tokyo Gas, Japan
- **Mikko Hupa** Abo Academy, Finland
- **Jost Wendt** Reaction Engineering, USA



# The IFRF Staff

- ◆ Director (part-time) Leo Tognoti
- ◆ Investigator Giovanni Corragio
- ◆ Part time investigator
- ◆ Administration Tracey Biller
- ◆ Consultant Neil Fricker
- ◆ Junior investig. (U of Pisa) L. Biasci, M. Marcucci
- ◆ Technician Marco Faleni

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Experimental Area: 12 engineers and technicians  
ENEL and UNIPI support 1 PhD student, 2 MSs,  
other students for projects

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- IT services: IVIN (NL), CPR (Pisa)
- Editing and web insertions: Patrick Levery
- Editors of Journal/Handbook: Pat Hughes, etc

# IFRF Experimental Capabilities

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- At its new Livorno location the IFRF has access to the ENEL research **facilities**.
- **IFRF has access for fixed periods to these state-of-the-art experimental facilities**, from lab to industrial scale, operated by dedicated personnel and with large availability of strategically important fuels.
- The facilities are available for the IFRF Members Research Programme and Members' test work, and on a **confidential** basis as well.



# IFRF Experimental Capabilities

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**500 kW furnace**



**2-8 MW single burner  
test rig "CA.SPER."  
liquid or gaseous fuels**



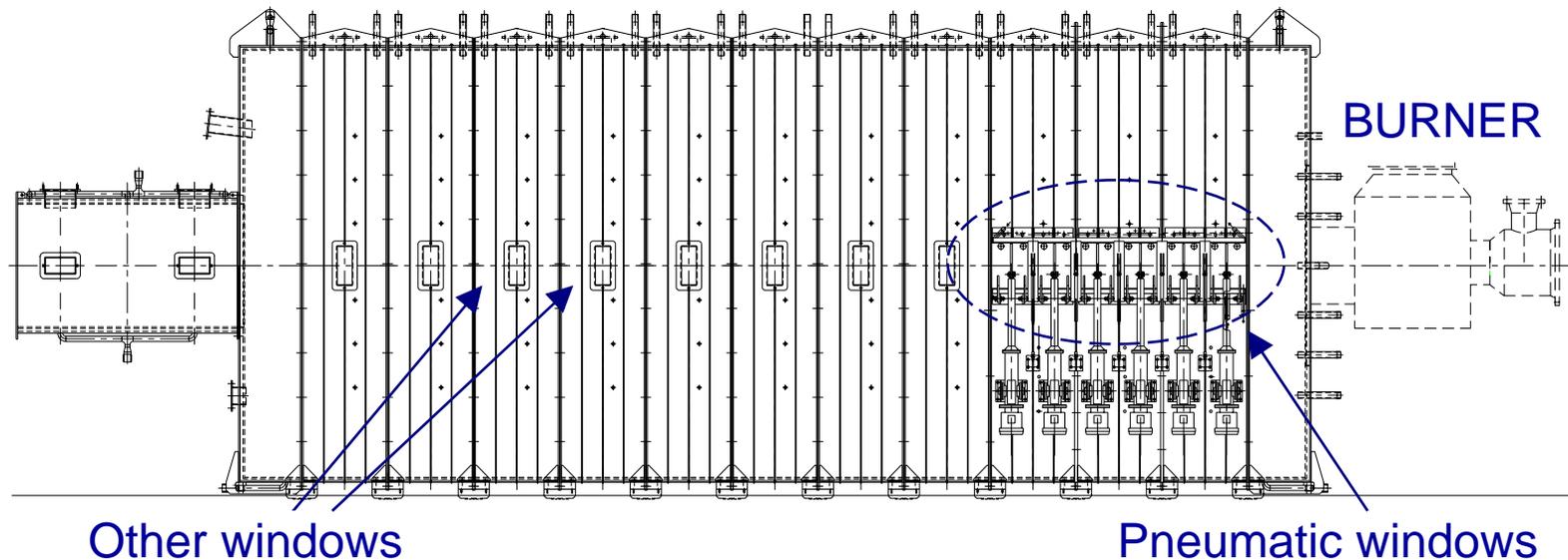
**5 MW single burner  
test furnace  
"FO.SPER"**



# IFRF Experimental capabilities : FOSPER

FOSPER (FOrnace SPERimentale – Experimental Furnace) is a replica of the former IFRF furnace number 1

- Dimensions: 2 m x 2 m x 6,25 m
- Fuels: solid fuels (coal, sec. fuels), oil and gas
- Refractory lined with external cooling
- Internal cooling loop and cooling pipe





# IFRF Services

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  - ◆ EFRI
  - ◆ Members Research Programme



# IFRF Services



<b>I</b>	<b>F</b>	<b>R</b>	<b>F</b>
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<b>IFRF Forums</b>			
<b>16th IFRF Members Conference</b>			
<b>Download 2008 IFRF Annual Report</b>			
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The IFRF - International Flame Research Foundation, an international centre of excellence for combustion research, technology and information.

<b>About us</b>	<b>Research Facilities</b>	<b>Members Research</b>
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<b>Industrial Combustion</b>	<b>The Monday Night Mail</b>	<b>Combustion Handbook</b>
<ul style="list-style-type: none"> <li>Aims and scope</li> <li>Latest papers</li> <li>List of papers</li> <li>Editorial board</li> <li>Propose a paper</li> <li>Management</li> </ul>	<ul style="list-style-type: none"> <li>What is it?</li> <li>Latest Edition</li> <li>Search</li> <li>Archive</li> </ul>	<ul style="list-style-type: none"> <li>Glossary</li> <li>New Combustion Files</li> <li>Filing System</li> <li>Search Combustion Files</li> </ul>
<b>Conferences, TOTeMs and Workshops</b>	<b>Events Calendar</b>	<b>Library</b>
<ul style="list-style-type: none"> <li>Overview</li> <li>Search</li> </ul>		<ul style="list-style-type: none"> <li>Search Document Archive</li> </ul>
<b>Members' Exchange</b>	<b>IFRF Academy</b>	<b>European Flame Research Initiative</b>
<ul style="list-style-type: none"> <li>Find Expertise</li> <li>Advice Bureau</li> <li>Members Lists</li> </ul>		

# IFRF Services : Online Library

- Cataloguing over 3500 IFRF Numbered documents.
- Developing and populating a searchable on-line index of all IFRF Documents
- Preparing PDF images of all 60,000 pages of archived documents.  
The majority of IFRF Documents created over the last 50 years still exist as hard copy in our archives.

These three elements form the basis of a **IFRF Library facility**.



The screenshot shows the IFRF website interface. At the top right, it displays the copyright notice: "© copyright 1999 - 2008 IFRF :: Wednesday 23 January 2008 ::". The main header features the "Monday Night Mail" logo and the URL "www.mnm.ifrf.net". Below the header, there is a navigation menu with "I", "F", "R", and "F" buttons. A "Go to week:" dropdown menu is set to "02" for the year "2008". The main content area features a news article titled "IFRF opens its Report Archive" from the IFRF Office, dated Monday 7th January 2008. The article text states: "During 2006, a complete inventory of the IFRF's physical and intellectual assets was undertaken as part of the transfer of the IFRF from the Netherlands to Italy. In the case of intellectual assets, the contents of the IFRF Reports Archive and the IFRF Library were entered into two electronic databases. PDF images were also made of all the archived IFRF reports to facilitate the dissemination of these documents electronically. The IFRF is pleased to confirm that with immediate effect, an on-line search of all archived IFRF reports and documents may be undertaken from the IFRF website at <http://www.library.ifrf.net/archive.html>. Searches may be made against words contained in the title, the abstract or the full text of IFRF documents, as well as by author. The Search Engine allows users to search against single or multiple entries in these search fields as well as against a combination of criteria in different search fields. Searches may be broadened or restricted using AND or OR conditions for the criteria selected."



# IFRF Services : Online Library

- more than 300 reports were electronically delivered in PDF format in last 2 years
- includes all papers delivered at each of the 15 Member Conferences
- PDFs of all TOTeM presentations and summaries for meetings **13 to 31** (except 18)
- The search engine is available at <http://www.library.ifrf.net/archive.html>



The screenshot shows the IFRF Document Archive Search Engine interface. At the top right, it displays the copyright notice: "copyright 1999 - 2009 IFRF :: Saturday 7 March 2009 ::". The main header is a red bar with the text "Document Archive Search Engine" and the URL "www.library.ifrf.net". Below the header, there is a search form with three dropdown menus: "Field" (set to "Title/Subtitle"), "Relation" (set to "Contains"), and "Search Term(s)" (empty). A "delete" link is next to the search term input. Below the form are "Search" and "Reset" buttons. On the left side, there is a navigation menu with the IFRF logo and a list of links: "Home", "About us", "Facilities", "Research", "Journal", "MNM", "Handbook", "Conferences", and "Events Calendar". The main content area contains a welcome message: "Welcome to the searchable index of the IFRF Document Archive." and a paragraph of text: "Here you can search some 4000 documents representing almost 60 years of IFRF research work and administration. Documents include technical and scientific studies, reports and published papers as well as facilities and planning records. The archive includes all documents published up until 31 December 2005. IFRF Members can directly download current reports (i.e. those published after 31 December 2005) from <http://www.research.ifrf.net/research/new.html>".



# IFRF services : Online Library



## IFRF Members Research Programme

ISSN 1607 - 9140      [www.research.ifrf.net](http://www.research.ifrf.net)

### Current reports

Current Reports are those published between January 2007 and the present date. They may be downloaded only by registered IFRF members and a valid user name and password will be requested. To access the IFRF's searchable database of archived reports (published prior to January 2007) go to [Search Document Archive](#).

### Published in 2009

**D 00/y/37 - IFRF Members' Research Programme - An agenda for 2010 to 2014**  
Authors: Neil Fricker, Hartmut Spliethoff, Leonardo Tognotti  
Publication date: September 2009      [Open Information](#) ◀  
Related programme: [Triennial Planning](#)

**F 110/y/01 - Combustion of NG and pulverised coal in a mixture of oxygen and RFG**  
Authors: Giovanni Coraggio, Michele Laiola  
Publication date: September 2009      [Open Information](#) ◀  
Related programme: [Validation of combustion modelling for practical combustion systems](#)

### Published in 2008

**E110/y/01 - In flame measurements of aerodynamic and chemical composition profiles**  
Authors: Giovanni Coraggio  
Publication date: October 2008      [Open Information](#) ◀  
Related programme: [Validation of combustion modelling for practical combustion systems](#)

**E 36/y/02 - Realisation of IFRF Solid Fuel Database Phase 1**  
Authors: Jarek Hercog, Leonardo Tognotti  
Publication date: March 2008      [Open Information](#) ◀  
Related programme: [IFRF Solid Fuel Database](#)

**D 10/y/01 - IFRF Solid Fuel Database - SFDB Phase 1**  
Authors: J. Hercog, L. Tognotti  
Publication date: January 2008      [Open Information](#) ◀  
Related programme: [IFRF Solid Fuel Database](#)

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### IFRF Forums

### 16th IFRF Members Conference

### Download 2008 IFRF Annual Report

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# IFRF services : Conferences and TOTeMs



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www.trends.ifrf.net

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## Events in 2010

**Computational Fluid Dynamics Validation Workshop**  
Renfew, Scotland, 16 June 2010  
Start date: 27-06-2010 Completed on: 10-07-2010

## Events in 2009

**Combustion characterisation techniques for pulverised coal**  
EDF IFRF Chatou France 23 November 2009  
Start date: 11-01-2010 Completed on: 31-12-2009

**Italian National Committee Seminar - Combustion Simulation, Diagnostics and Experimentation**  
Università degli Studi, Milan 14 July 2009  
Start date: 17-07-2009 Completed on: 27-07-2009

**16th Members' Conference - Combustion and Sustainability: New Technologies, New Fuels, New Challenges**  
Boston, USA, 8-10 June, 2009  
Start date: 26-06-2009 Completed on: 29-06-2009

**TOTeM 33 - Challenges in Rotary Kiln Combustion Processes**  
Pisa, Italy, 11-12th February, 2009  
Start date: 18-02-2009 Completed on: 23-02-2009

## Events in 2008

**TOTeM 32 "Efficient solid fuel utilisation: How to overcome ash related restrictions"**  
Freising Germany, 15th, 16th December 2008  
Start date: 15-12-2008 Completed on: 16-12-2008

**TOTeM 31 "Oxy-Combustion technologies and applications"**  
ENEL Auditorium, Pisa 13,14 November 2008  
Start date: 19-11-2008 Completed on: 24-11-2008



# IFRF services : Conferences and TOTeMs



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**IFRF Forums**

**16th IFRF Members Conference**

## Computational Fluid Dynamics Validation Workshop

Type: Workshop Presentation  
Publication date: July 2010  
Authors: Various  
Referee: Leo Tognotti  
Sub-Editor: Neil Fricker

- [39 kB] [CFD Validation Workshop Agenda](#)
- [27 kB] [CFD Validation Workshop Delegate List](#)
- [7199 kB] [IFRF background and introduction - L. Tognotti](#)
- [816 kB] [Background to previous workshops, and introduction - R. Waibel and N. Fricker](#)
- [1243 kB] [Validation of a Coal Combustion Model against FOSPER Data - A. Duncan and A. Parera](#)
- [5579 kB] [Oxy-Fuel 'Burners' - Validation and Uncertainty Quantification - J. Thornock and P. Smith](#)
- [1154 kB] [Development of CFD modelling for Oxy-fuel combustion - K. Eriksson](#)
- [2008 kB] [Oxy-combustion tests on low-NOX burners at FO.SPER. Furnace - G. Coraggio et al.](#)
- [2875 kB] [Full scale validation approaches - B. Risio](#)
- [901 kB] [Comparing two CFD combustion models using coke oven gas data - E. George](#)
- [754 kB] [EDC model set-up for simulation of regenerative burner - U. Zanussi et al.](#)
- [63 kB] [CFD Validation Workshop Conclusions - R. Waibel and N. Fricker](#)



# IFRF services : Conferences and TOTeMs

**TOTeM 34** – rescheduled to take place in Cardiff 20/21 October

**“Status of the Research Requirements for Gas Turbines- Fuels, Combustion and Environmental Protection”**

preceded on 19 Oct by second **EFRI** meeting.

<p><b>Organising Committee:</b></p> <p><b>Allan Jones</b> Director, E.ON Engineering</p> <p><b>Cath Goy</b> E.ON Engineering UK Ltd. and Vice-Chair ETN.</p> <p><b>Leo Tognotti</b> Director, IFRF</p> <p><b>Phil Bowen</b> Director, GTRC Deputy Director, Cardiff School of Engineering</p> <p><b>Peter Jansohn</b> Head of Department, General Energy, PSI Switzerland</p> <p><b>Nell Fricker</b> IFRF, Italy</p> <p><b>Peter Roberts</b> Co-ordinator, Cardiff University</p> <p>Overseas: is the final programme. Enquiries about the meeting or expressions of interest in participating in panel discussion and/or in presenting a poster may be addressed to the co-chairmen.</p> <p>????? Soandso@whatever.com</p> <p>????? Soandso@whatever.com</p> <p>Deadline for poster submission: ????????</p>	 <p><b>INTERNATIONAL FLAME RESEARCH FOUNDATION</b></p> <p>Something about the theme etc. To be added</p> <p>This conference will be of interest to the following To be added</p> <p><b>Topics for discussion:</b></p> <ul style="list-style-type: none"> <li>•Gas turbines of the future—the need for research</li> <li>•Gas turbine combustion and alternative fuels</li> <li>•Combustion instabilities and operation</li> <li>•Combustion chemistry and emissions formations chemistry</li> <li>•Gas turbines emissions and environmental protection</li> <li>•Computer based simulation for design</li> <li>•Gas turbines for the future—an Eastern European perspective</li> <li>•Infrastructures for gas turbine research</li> </ul> <p><b>Key participants:</b></p> <ul style="list-style-type: none"> <li>•Professor Allan Jones, E.ON</li> <li>•Professor Peter Jansohn, PSI Switzerland</li> <li>•Professor Artem Khalatov, National Academy of Sciences, Ukraine</li> </ul> <p>So far agreed</p>	<p><b>TOTeM34</b> 34th IFRF Topic Oriented Technical Meeting</p> <p><b>22nd and 23rd April 2010</b> Car Casella di testo</p> <p><b>GAS TURBINE RESEARCH FUELS/COMBUSTION ENVIRONMENTAL PROTECTION</b></p> <p>Joint Chair</p> <p>Professor Allan Jones Managing Director E.ON Engineering Gelsenkirchen, Germany and Nottingham, UK</p> <p>Dr Cath Goy Team Leader Combustion Technology E.ON Engineering UK</p> <p><a href="http://www.cu-gtrc.co.uk">www.cu-gtrc.co.uk</a> <a href="http://www.ifrf.net">www.ifrf.net</a></p> <p><b>Thursday 22nd April 2010</b></p> <p>Cardiff University Cardiff Wales UK</p> <p><b>Friday 23rd April</b></p> <p>Gas Turbine Research Centre Port Talbot Wales UK</p>    
 		

# IFRF services : Conferences and TOTeMs

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## TOTeM 35

**“Co-firing secondary fuels in power generation: from fuel characterization to full scale testing”**

23-24 September 2010, Pisa, Italy

### TOTeM 35 topics for discussion:

- *Biomass and bio-waste production, supply and quality control;*
- *Biomass and secondary fuels characterisation;*
- *Assessment of solid bio-fuels co-firing characteristics in lab and pilot scale;*
- *Ash related problems: slagging, fouling and corrosion, fine particulate generation;*
- *Kinetics and phenomenological modelling of different phenomena;*
- *Full-scale co-firing tests: methodologies and procedures for planning, executing, analysing, reporting*



# IFRF services : Conferences and TOTeMs


Calendar of technical events  
[www.calendar.ifrf.net](http://www.calendar.ifrf.net)

Events in chronological order
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Coming events:

[23rd-24th Sep 2010](#)  
TOTeM 35 - Co-firing secondary fuels in power generation: from fuel characterization to full scale testing

[26th-29th Sep 2010](#)  
AFRC Pacific Rim Combustion Symposium

[30th Sep - 1st Oct 2010](#)  
TOTeM 36 - Industrial Flares

[12th-13th Oct 2010](#)  
COMBURA 2010

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September 2010

**TOTeM 35 - Co-firing secondary fuels in power generation: from fuel characterization to full scale testing** **23rd-24th Sep, 2010**  
IFRF TOTeMs, Workshops and other supported Meetings

Santa Croce in Fossabanda, Pisa

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**AFRC Pacific Rim Combustion Symposium** **26th-29th Sep, 2010**  
IFRF TOTeMs, Workshops and other supported Meetings

Maui, USA

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**TOTeM 36 - Industrial Flares** **30th Sep - 1st Oct, 2010**  
IFRF TOTeMs, Workshops and other supported Meetings

Maui, USA

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October 2010

**COMBURA 2010** **12th-13th Oct, 2010**  
Other Combustion meetings

Vaeshartelt Castle, Maastricht, The Netherlands

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**Les Enjeux de la Combustion enrichie en oxygène** **Thu, 14 Oct, 2010**  
IFRF Flame Days

Espace Hamelin, Paris 16  
IFRF, Combustion Institute Joint Meeting

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**Challenges in the Design and Operation of High Pressure Combustion Test Rigs** **Tue, 19 Oct, 2010**  
IFRF TOTeMs, Workshops and other supported Meetings

EFRI Technical Meeting  
Cardiff University Gas Turbine Research Centre, Port Talbot, Wales

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**TOTeM 34 - Gas Turbine Research: Fuels, Combustion, Heat Transfer and Emissions (NEW DATES)** **20th-21st Oct, 2010**  
IFRF TOTeMs, Workshops and other supported Meetings

Cardiff University and CU Gas Turbine Research Centre, Wales



# IFRF services : Industrial Combustion Journal

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**IFRF Forums**

**16th IFRF Members**

## Editorial Board

There are three groups concerned with the management of the Journal: the Editorial Board, the Executive and the Secretariat.

The Editorial Board is responsible for overseeing the technical merit and industrial relevance of the Journal, and also encouraging the publication of combustion topics.

**Editor-in-Chief:** Pat Hughes, Canmet, Canada  
**Chairman Editorial Board:** Prof. Mikko Hupa, Åbo Akademi University, Finland

- Tetsuo Akiyama**, Chugai Ro, Japan
- Prof. John M. Beer**, MIT, USA
- Frank Fitzgerald**, British Flame, UK
- Neil Fricker**, University of Glamorgan, UK
- Prof. Klaus Hein**, IVD, Germany
- Jaan Hellat**, Alstom Power, Switzerland
- Prof. Fred Lockwood**, Imperial College, London, UK
- Tom Lowes**, CINAR Ltd, UK
- Keiji Makino**, IHI, Japan
- Sigfrid Michelfelder**, Steinmueller Engineering, Germany
- Peter Roberts**, Cardiff University, UK
- Prof. Dirk Roekarts**, TU Delft, NL
- John Smart**, RWE npower, UK
- Prof. Lasse Stromberg**, Vattenfall, Sweden
- Prof. Leo Tognotti**, University of Pisa and IFRF, Italy
- Prof. Terry Wall**, University of New South Wales, Australia
- Prof. Roman Weber**, TU Clausthal, Germany
- Prof. Jost Wendt**, Reaction Engineering International & RWTH Aachen University, Germany
- Prof. Alan Williams**, University of Leeds & Journal of Energy Institute, UK

## Aims and scope

The Journal's objective is to further the application of scientific principles in stationary combustion technologies for large scale industrial heating processes leading to clean and efficient fuel conversion. Our emphasis is on industrial sectors such as:

- Power generation,
- Petroleum refining, petrochemical and chemical manufacturing
- Iron and steel and non-ferrous metal production,
- Cement and mineral processing
- Glass manufacturing
- Industrial combustion equipment
- Fuels and industrial gas production and utilisation

Technical subjects emphasised include:

- Atmospheric pollution and its control
- Efficient combustion in industrial furnaces
- Flames and burners
- Modelling and scaling in combustion process
- Furnace heat transfer
- Fuel character and combustion properties for gas, liquid and solid fuels
- Combustion measurement techniques
- New combustion technologies
- Combustion of wastes

We pay particular attention to technologies related to reducing green house gas emissions. Areas of particular interest:

- Oxygen enriched combustion
- Slagging, fouling and ash effects
- Process control systems and instrumentation
- Fuel conversion (including gasification)
- Simulation of processes and control
- Technical/economic evaluation of projects and processes
- Fluidised bed combustion
- Grate fired combustion

Click [here](#) to propose a paper.

# IFRF services : Industrial Combustion Journal



**Industrial Combustion**  
Journal of the International Flame Research Foundation ISSN 2075-3071

**I F R F**

Use the search option to search by title, author, abstract and keywords.

Search papers:

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**Papers**

**Sep-10 Numerical studies of the integration of a Trapped Vortex Combustor into traditional combustion chambers**  
*L. Patignani, M. Losurdo, C. Bruno*  
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**Jun-10 Reuse of Partially Sulphated CFBC Ash as an SO<sub>2</sub> Sorbent**  
*Yinghai Wu, Marianna Nobili, Antonio Telesca, Fabio Montagnaro, Lufei Jia, Edward J. Anthony*  
[Abstract](#) | [PDF](#)

**Apr-10 On the Potential of Flameless Oxidation to Reduce NO<sub>x</sub> Emissions from Pulverized Coal Combustion**  
*D. Ristic, A. Schuster, G. Scheffknecht*  
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**Aug-09 Emissions performance of a 40 MW pulverised wood fired boiler**  
*Olof Stålnacke, Björn Zethräus*  
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**Jun-09 Accurate Numerical Computation of the Beta PDF**  
*Eduardo A. Brizuela, Willem Deconinck, Chris Lacor*  
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**Mar-09 CARS and Heat Flux Measurements in Regenerative and Conventional Industrial-Scale Burners**  
*P. M. Hughes, R. J. Lacelle, A. Idris, M. Legere, D. Percy, J. Wong, T. Parameswaran*  
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**Nov-08 A Comparative Study of Turbulence Modelling in Diluted Hydrogen Non-premixed Flames**  
*F. Tabet-Helal, B. Sarh, I. Gökalp*  
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**May-08 Experimental method to verify the real residence-time distribution and temperature in MSW-plants**  
*Olof Stålnacke, Björn Zethräus, Sirkku Sarenbo*  
[Abstract](#) | [PDF](#)

**Jan-08 A Self-Consistent CFD-model for Pressurised High Temperature Black Liquor Gasification**  
*M. Marklund, R. Tegman, R. Gebart*  
[Abstract](#) | [PDF](#)

**Aug-07 Optical windows for combustion research and control applications: Anti-fouling strategies**  
*Helmut Ranner, Franz Winter*  
[Abstract](#) | [PDF](#)

**Jul-07 Towards industrial application of High Efficiency Combustion**  
*B.T. Burmraaf, B. Lewis, P.D.J. Hoppesteyn, N. Fricker, S. Santos, B.K. Slim*

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**IFRF Forums**

**16th IFRF Members Conference**

**Download 2008 IFRF Annual Report**

**Request membership**



# IFRF Services : On-line Handbook

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- Searchable knowledge source
- Short, concise Combustion Files designed to answer basic questions :
  - ◆ « What is .... ? »
  - ◆ « How do I ..... ? »
  - ◆ « What data is available for ... ? »
- About 300 Combustion Files
- Some files available only to IFRF Members
- Glossary



I F R F

## Combustion Handbook

Front page  
Glossary  
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Combustion



## The Filing System

### The Combustion Files

-   Administration
-   Basic Scientific Principles
-   Burners
-   Emissions
  -   Dioxins
  -   Emission Limits
  -   Metals
  -   Nitrogen Oxides
    -   Formation
      -  [40 - How do I calculate thermal NO<sub>x</sub> formation due to Zeldovich?...](#) - Members' Domain
      -  [41 - What is the relationship between fuel nitrogen and NO<sub>x</sub> emissions?...](#) - Members' Domain
      -  [42 - What are the mechanisms for Prompt NO<sub>x</sub> formation during combustion?...](#) - Members' Domain
      -  [66 - What are the main NO<sub>x</sub> formation processes in combustion plant?...](#) - Open Domain
      -  [180 - What is the gas-phase mechanism for NO formation from N<sub>2</sub>O and when is this ...](#) - Members' Domain
    -   Reduction
    -   Environmental Impact
  -   Noise
  -   Soots and Particulates
-   Flames
-   Fuels and Comburents
-   Measurements
-   Modelling
-   Power Generation
-   Slagging, Fouling and Corrosion

[Front page](#)[Glossary](#)[New Combustion Files](#)[Filing System](#)[Search Combustion Files](#)[Forum](#)[Converter](#)[Log into backroom](#)Help Members Sites IFRF Links Open Services The Network Online  
Combustion  
Centre

Combustion



Journal

# Glossary

Search glossary:

<b>A-weighted sound pressure levels</b>	Sound pressure level indicated when the incident sound pressure is weighted to reflect the frequency response of the human ear
<b>AAS</b>	Acronym - Atomic Absorption Spectrometry
<b>Absorption coefficient</b>	The fractional attenuation of a beam of radiation per unit distance through a gaseous medium per unit pressure (atmosphere) of absorbing gas component. Units are m-1atm-1. Term often used to mean Extinction Coefficient
<b>Absorptivity</b>	The fraction of radiation incident on a surface that is absorbed.
<b>Acidification</b>	Acidification is a complex chemical and atmospheric phenomenon that occurs when emissions of sulphur and nitrogen compounds and other substances are transformed by chemical processes in the atmosphere, often far from the original sources, and then deposited on earth in either wet or dry form. The wet forms, popularly called "acid rain," can fall to earth as rain, snow, or fog. The dry forms are acidic gases or particulates
<b>Activated carbon</b>	Carbon, usually in a ground form, that has been treated to have extra functional groups, used widely for adsorption of air and water pollutants, due to its adsorptive ability and high surface area. Carbon sources for activated carbon production include coconut shells, coal, wood and lignite.
<b>Activation energy</b>	The external energy that must be provided to reactants in order to initiate a reaction. The combination of this energy with the internal enthalpy of the reactants is sufficient to break the reacting molecules into their constituting atoms.
<b>Acute</b>	Medical. Having a rapid onset and following a short but severe exposure
<b>Adiabatic flame temperature</b>	Refers to the theoretical flame temperature assuming no heat losses. It is computed by equating the lower heating value of the fuel to the enthalpy of combustion products corresponding to a unit mass of fuel and to a known excess air (but assuming no recirculation)



# IFRF services : Training and education

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**In the past: IFRF trained combustion engineers:**  
over 80 former investigators – European, Japanese, Americans,  
Australians, Canadians

## Advanced courses in 2008-2009

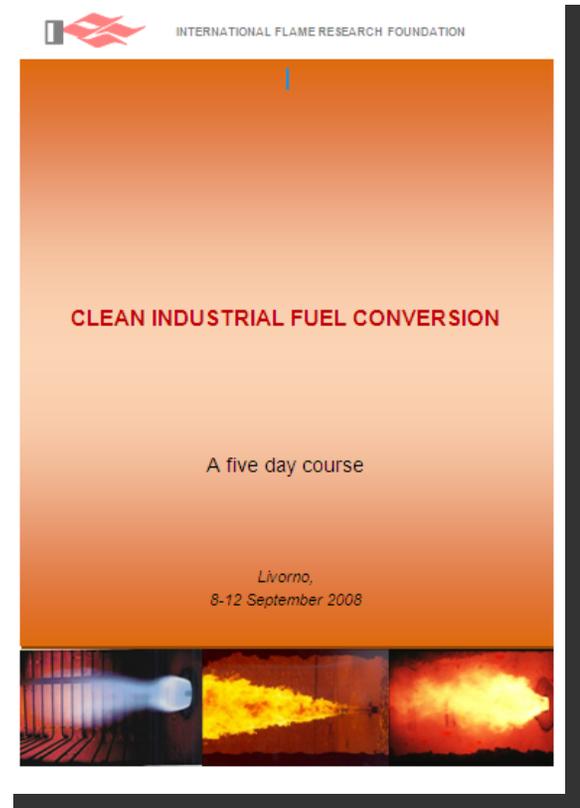
First IFRF Training Course held at Livorno  
in September 2008 – K.Hein Coordinator  
5 days-High quality speakers from Industry and Academia

## Further courses planned:

Early 2011 Poland: ***Solid fuel utilisation***

Late 2011 China: **under development**

Reactivation of mobility of investigators from industry on the MRP  
and through courses



# IFRF Networking and Research Activities

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- IFRF organization
  - ◆ Mission
  - ◆ Members
  - ◆ Industrial sectors
  - ◆ Experimental facilities
- Services provided by the IFRF
  - ◆ On-line library
  - ◆ Conferences and TOTeMs
  - ◆ Industrial combustion Journal
  - ◆ Electronic handbook
  - ◆ Training and education
- Networking and research activities at IFRF
  - ◆ EFRI
  - ◆ Members Research Programme



# IFRF Networking and Research Activities - EFRI

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## EFRI : European Flame Research Infrastructure

- Network of EU Member Organisations sharing their combustion facilities (CNRS, GdF Suez, Cardiff University, GWI, ENEL, DTU, ETC, IFRF)

## Short and Medium term Objectives

- Create the European Combustion Facilities Database
- facilitate definition and sharing (through *benchmarking*) of measurements on different facilities, **protocols and procedures** for testing components and systems
- share **novel/advanced measurement techniques and diagnostics**, to extend the use of lab scale diagnostics to large scale combustion facilities
- by means of **databases**, allow development and validation of modelling tools (i.e. CFD).



# IFRF Networking and Research Activities - EFRI

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## EFRI Initiatives

- **EFRI web site** including a **searchable directory of European Combustion Test Rigs**: <http://dev.efri.ifrf.net/search.html>
- **EFRI Technical Meetings** - *high pressure combustion rigs* (associated with TOTeM34 in Cardiff, UK in October) and the *use of oxygen on test rigs* (associated with the Joint Committee Meeting at Doosan Babcock, Glasgow, UK in June)
- **Bids for Infrastructure or Cooperative Research funding from EU**  
In December 2009 10 Million Euro funding request **Research Infrastructures for Biomass Conversion and Biorefineries** was developed and submitted by IFRF and 14 EFRI Members participating in a 23 Member Consortium.
- **On-line EFRI Forum** established



# IFRF Research - 2009 Highlights



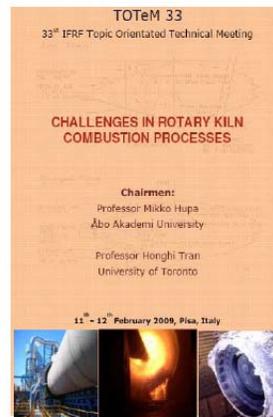
## ANNUAL REPORT and SUMMARY FINANCIAL STATEMENTS 2009



Prepared by:  
Leonardo Invernizzi, Director IFRF

With a message from  
Dick Weibel, President IFRF

- **TOTeM 33 and 16<sup>th</sup> IFRF International Members' Conference** organised
- **Online forums** established to facilitate Members Research and EFRI projects
- **EFRI - database of European rigs**
- **IFRF Journal** relaunched as “**Industrial Combustion**”
- **IFRF document archive** well utilised



## 16<sup>th</sup> IFRF Members' Conference Combustion and Sustainability: New Technologies, New Fuels, New Challenges



Boston, USA

8-10 June 2009

CONFERENCE PROGRAMME

AMERICAN FLAME RESEARCH COMMITTEE



# IFRF Research - 2009 Highlights

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- **Research activity on flame characterisation** continues on replica IFRF No 1 furnace: gas and coal in oxy-fuel combustion.
- **Isothermal Plug Flow Reactor** produces characterisation results on different coals.
- **Measurement probe** manufacturing activity continues
- **Validation and Verification and Uncertainties Quantification (V&V-UQ)** approach starts to be circulated through IFRF scientific community
- **2 technical reports** issued.
- **3 refereed Journal papers** published.
- **2 IFRF papers** accepted for presentation at the **XXXIII Int. Symposium on Combustion.**



**ANNUAL REPORT  
and  
SUMMARY FINANCIAL STATEMENTS  
2009**



Prepared by:  
Leonardo Lognotti, Director IFRF

With a message from  
Dick Waibel, President IFRF



# IFRF Research - Papers published 2009

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Results of the research performed at IFRF in the triennial are also included as papers in the **Proceedings of the 16th IFRF Members' Conference, Boston,**

- *Estimation of uncertainties in experimental data and model predictions for a semi-industrial furnace, A.Parente, G. Coraggio, C. Galletti, L.Tognotti*
- *Numerical modelling of oxy-fuel experiments in a semi-industrial furnace. J. Brunetti, N. Rossi, C. Galletti, L. Tognotti*
- *Kinetic combustion parameters for chars using the IFRF solid fuel data base,* J.Hercog, O. Karlstrom, A. Brink, M. Hupa, L. Tognotti,
- *Characterisation of solid fuels by isothermal plug flow reactors: a methodology for qualification of the devices and the procedures,* J. Hercog, E. Biagini, L.Tognotti
- *Oxy-combustion tests on low NOx burners at Fo.Sper. furnace* G.Coraggio, M.Laiola, D.Cumbo, N.Rossi, L.Tognotti



# IFRF Members' Research Program



IFRF Document Number D 0/y/37  
Livorno, June 5<sup>th</sup> 2009  
DRAFT FOR DISCUSSION

## IFRF MEMBERS RESEARCH PROGRAMME

### AN AGENDA FOR 2010-2014

Hartmut Spliethoff<sup>1</sup>, Neil Fricker<sup>2</sup> and Leo Tognotti<sup>3</sup>

IFRF  
Via S.Orlando 5, 57100 Livorno  
ITALY

<sup>1</sup> Superintendent of Research, Technical University of Munich, Germany

<sup>2</sup> Deputy Superintendent of Research, University of Glamorgan UK,

<sup>3</sup> Director, IFRF

<sup>2</sup> Presenting Author: neil.fricker@ifrf.net

#### ABSTRACT

This document outlines the combustion related business issues facing IFRF Member Organisations, and the perceived technology gaps that relate to them. It goes on to propose an Agenda for the IFRF Members' Research Programme for 2010/14 that will help address the technology gaps.

#### 1 BACKGROUND

The IFRF was founded over 50 years ago with the objective of generating and disseminating, through a programme of shared research, new information relating to the clean efficient use of fuels in industrial scale processes. For at least the last 30 years, this research activity has been based around frameworks prepared by the Superintendents of Research and the IFRF Director on behalf of the IFRF's Members and its Board, the Joint Committee for Flame Research. The framework is based around opinions and views collected from IFRF Members, as well as the experience of its authors.

The agenda proposed in the present document is based on views collected at and since the IFRF's 15<sup>th</sup> Members Conference in 2007, including:

- Topic Orientated Technical Meetings (TOTeMs):
  - TOTeM 30, Mathematical Modelling of Flames, Hawaii, 2007
  - TOTeM 31, Oxy-Combustion, Pisa, 2008
  - TOTeM 32, Ash related restrictions on solid fuel utilisation, Munich, 2008
  - TOTeM 33, Rotary Kilns, Pisa, 2009
- Members Workshops
  - 15<sup>th</sup> Members Conference, CFD Workshop, Pisa, 2007
  - 15<sup>th</sup> Members Conference, Solid Fuel Database Workshop, Pisa, 2007
  - CFD Validation Workshop, Munich, 2008
  - Solid Fuels database Workshop, Munich, 2008
- IFRF National Committees:
  - 155<sup>th</sup> Meeting of the IFRF Joint Committee, 2008
  -

The questions posed in each case were:

- What are the Combustion Related Business Issues facing IFRF Members?
- What gaps exist in the technology needed to address these business issues?

## Planning the research for 2010-2014

What is important for the  
IFRF Members?:

Network activities  
and  
experimentally based  
research at a  
*reasonable* scale:

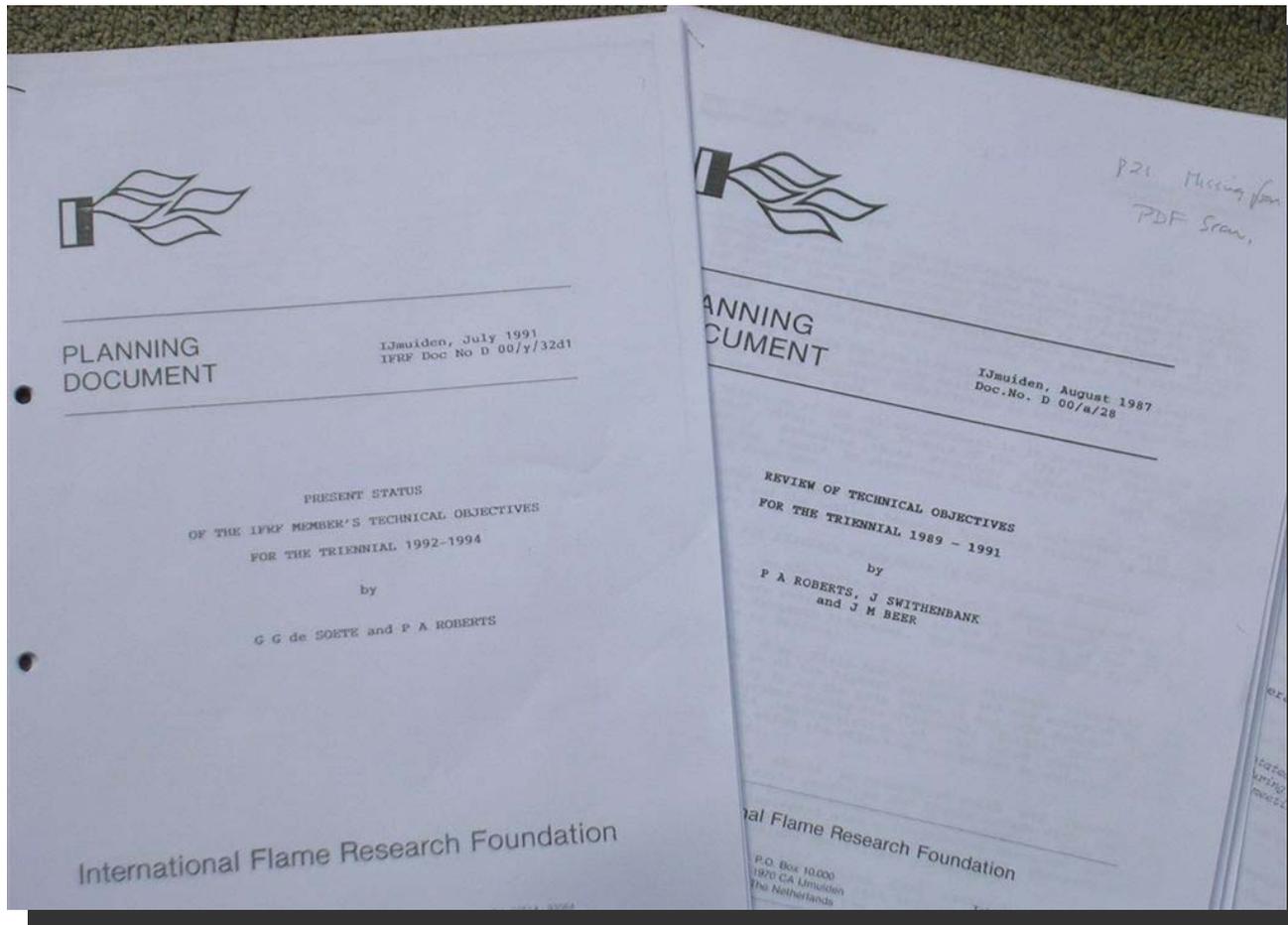
**the Members'  
Research Program**



# IFRF Members' Research Program : Background

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- IFRF Research Programme regularly reviewed by Superintendents of Research and the IFRF Director



# IFRF Members' Research Program

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Based on views collected since June 2007

## ◆ TOTeMs

- T30, Mathematical Modelling, Hawaii, 2007
- T31, Oxy-Combustion, Pisa, 2008
- T32, Ash, Munich, 2008
- T33, Rotary Kilns , Pisa, 2009

## ◆ IFRF Members Workshops

- 15<sup>th</sup> MC CFD Workshop, Pisa, 2007
- 15<sup>th</sup> MC Solid Fuels Database Workshop, Pisa 2007
- CFD Validation Workshop, Munich, 2008
- Solid Fuels Database Workshop, Munich, 2008
- 16<sup>th</sup> MC CFD V&V Workshop, Boston, 2009
- 16<sup>th</sup> MC Flameless Combustion Workshop, Boston, 2009

## ◆ IFRF Joint Committees

- 155<sup>th</sup> Joint Committee Meeting, Pisa, 2008
- 156<sup>th</sup> Joint Committee Meeting, Boston, 2009
- 156<sup>7h</sup> Joint Committee Meeting, Renfrew, 2010



# IFRF Members' Research Program

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## Questions posed

- What are the **combustion related business issues** facing IFRF Members?
- What **gaps exist in the technology** needed to address these business issues?
- **What R&D is needed** to fill these gaps?
- What **Research Agenda** does this suggest for IFRF for the next planning cycle (2010-2014)
- What **actions** are needed to turn 'Agenda' into 'Needs' & 'Deliverables'?



# IFRF Members' Research Program

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## Business Issues

- **Environment (>50%)**
- Economics
- Design & Operation
- Reliability



# IFRF Members' Research Program

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## Technology Gaps

- **Modelling (> 60%)**
  - ◆ No 1 in technology meetings **and** business meetings
- Deposits
- Fuels
- Combustion- (oxy/flameless....., stability,..)
- Measurements
- Particulates



# IFRF Members' Research Program

---

## R&D Needs

- 28 R&D needs surfaced during the various meetings
- These could be grouped under 9 headings
  - ◆ Modelling (>40%)
  - ◆ Measurement
  - ◆ Fuels
  - ◆ Ash, fouling, slagging, corrosion
  - ◆ Combustion
  - ◆ Nitrogen Oxides
  - ◆ Information (exchange)
  - ◆ Training
  - ◆ Noise



# IFRF Members' Research Program : 2010 – 2014 Agenda

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- IFRF cannot act alone

- ◆ **Focus** in one or two of areas identified

- ◆ **Take account of diverse needs** in

- National Committees
- Industrial Sectors
- 4 years is too long for any NC or Industry Sector to support IFRF and see no directly relevant return

- ◆ Recognise **resource limitations**

- Limited internal R&D funds from Membership fees
- Small size of permanent core team

- ◆ Take advantage of its **strengths**

- Large international spread of industrial and academic members
- Access to world class facilities at its Livorno base
- Knowledge base accumulated over 60 years



# IFRF Members' Research Program : 2010 – 2014 Agenda

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## (1) – Modelling

- Prepare **Position Paper on numerical modelling of flames**  
*Industrial Combustion Journal*
- Propose **Protocols** for sharing experimental data
  - ◆ Create **inventory of 'shareable' data** (IFRF, Members, Others)
  - ◆ Implement a **data sharing** exercise with its Members & contributing partners
- Establish **Multi-partner programme** to:
  - ◆ Develop and agree criteria for validating (= quantify uncertainties) mathematical models
  - ◆ Apply the criteria across a range of models, processes and fuels



# IFRF Members' Research Program : 2010 – 2014 Agenda

---

## (2) - Measurements

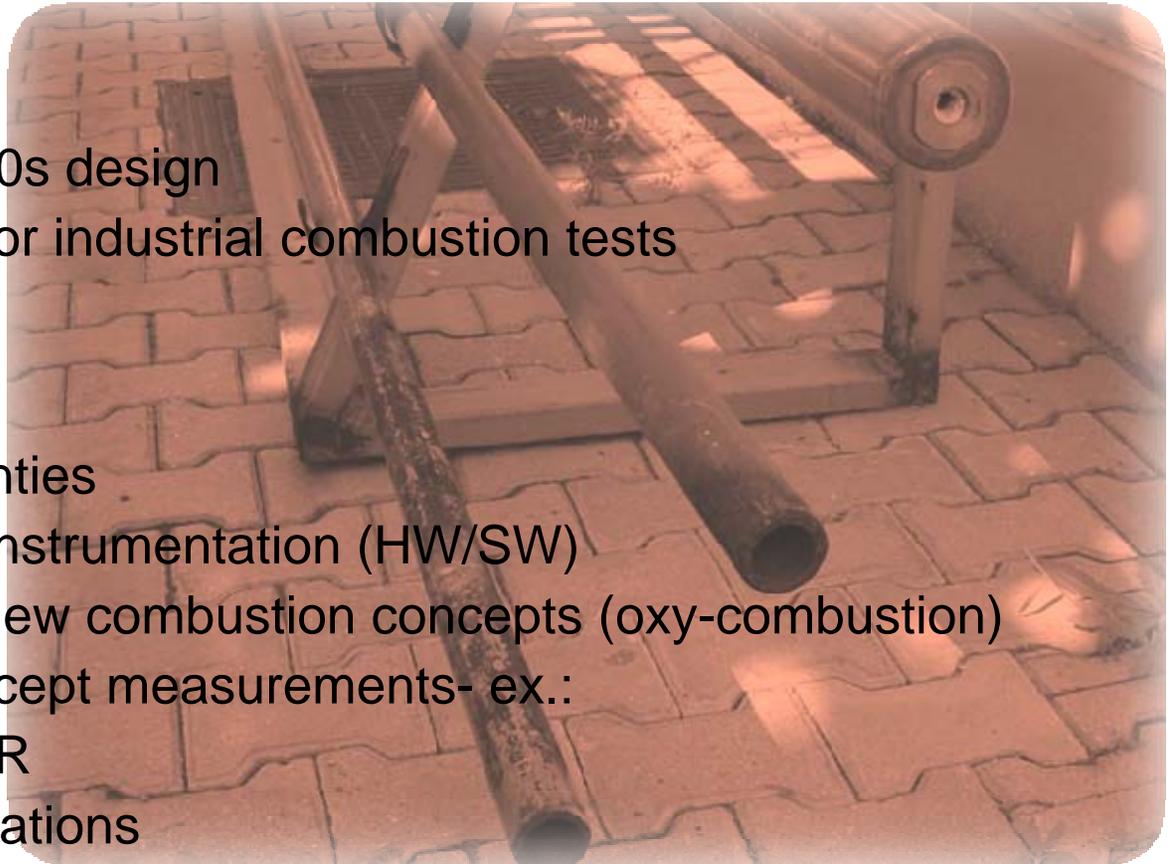
**Review in-flame and in-furnace measurement techniques**  
(IFRF and others)

### IFRF probes

- Based on early '60s design
- Still widely used for industrial combustion tests

### Today needs

- Quantify uncertainties
- Update/upgrade instrumentation (HW/SW)
- Adapt probes to new combustion concepts (oxy-combustion)
- Develop new concept measurements- ex.:
  - ◆ in-flame FTIR
  - ◆ Flame fluctuations



# IFRF Members' Research Program : 2010 – 2014 Agenda

## (3) - Measurements

- Undertake **experimental work on Livorno pilot scale furnaces**
  - ◆ To fill gaps in data required for numerical model validation
    - Incomplete or unreliable data
    - Helps quantify experimental uncertainties
    - Creates data for new fuels and/or comburents
    - Extends range of stationary processes in IFRF portfolio
  - ◆ Also contributes practical experience on
    - Combustion & co-comb. for biomasses & wastes
    - Firing solid fuels in oxy/RFG atmospheres
    - Looks at novel combustion techniques



RESEARCH  
REPORT

Livorno, June 2009  
IFRF Doc. No F110/y/01

**Combustion of NG and pulverized  
coal in a mixture of oxygen and  
RFG**

Prepared by  
**G. Coraggio, M. Laiola**

Approved by  
**L. Tognotti**

<http://www.research.ifrf.net>

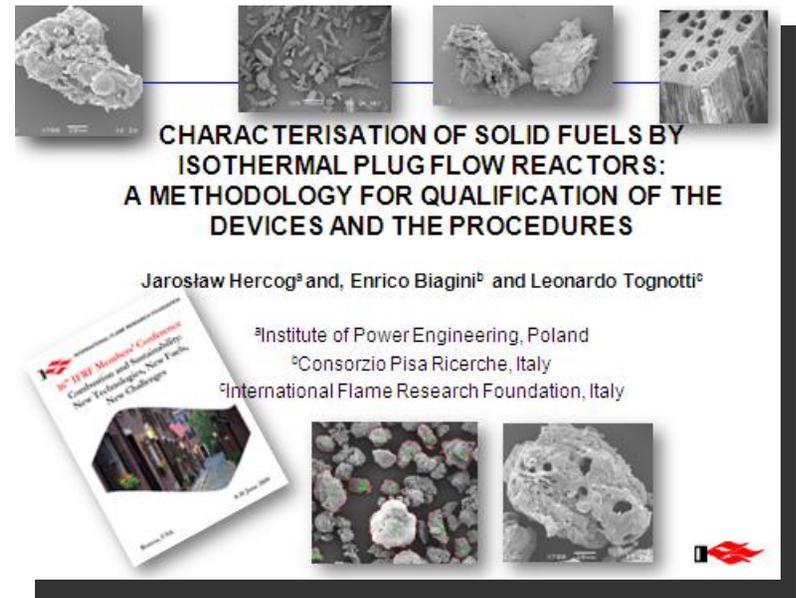
**INTERNATIONAL FLAME RESEARCH FOUNDATION**

REGISTERED OFFICE 06/Presidenza Facoltà di Ingegneria, Via Cristoforo 2, 56126 Pisa, Italy CF: 8306990050	OPERATIONS CENTRE Via Salvatore Orlando 5, 57123 Livorno, Italy	CONTACT NUMBERS Tel: +39 0586 891878 Fax: +39 0586 200465 e-mail: <a href="mailto:info@ifrf.net">info@ifrf.net</a> <a href="http://www.ifrf.net">http://www.ifrf.net</a>	BANK IBAN: IT 90 M 0630 14011 000000086187 Cassa di Risparmio Lucina Pisa Livorno Swift: BPAIT33XXX VAT no. 01807000508
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# IFRF Members' Research Program : 2010 – 2014 Agenda

## (4) - Fuel characterisation

- Establish protocols for solid fuels combustion characterisation
  - ◆ International
  - ◆ Members & non-members
  
- Characterise solid and liquid fuels
  - ◆ to agreed protocols
  - ◆ To fill data gaps for numerical model validation & application
  - ◆ Includes fuels that are environmentally significant
    - Biomass
    - Wastes
    - Blends of above with coals
    - In atmospheres that reflect O<sub>2</sub>/RFG, temperatures and pressures
    - Liquid biofuels



# IFRF Members' Research Program : 2010 – 2014 Agenda

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## (5) - Training

- Continue IFRF's tradition of training combustion engineers through
  - ◆ Repeating and further developing the classroom based training activity started in 2008
  - ◆ Recruiting and/or seconding young engineers to work for extended periods on the experimental rigs at Livorno
  - ◆ Offering opportunities for Members' engineers to experience a shorter term 'close encounter' with industrial scale flames
  - ◆ Seeking EU support to develop a Europe wide 'Access' programme to a network of combustion research facilities (EFRI)
  - ◆ Replicating the above in North America and the Pacific areas in partnership with AFRC and JFRC (AFRI? PaFRI?)



# IFRF Perspectives

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## The IFRF will continue

- to be the bridge between industry and fundamental research
- the International networking: *research programmes*
- to educate experienced *combustion* engineers
- to disseminate knowledge through the scientific community

<http://www.ifrf.net>





See you in Tuscany.....

