INTERNATIONAL
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POWER CYCLE CHEMISTRY WORKING GROUP (PCC WG)

IAPWS PCC Webinars

Introduction to IAPWS and the Power Cycle Chemistry Working (PCC) Group

- **David Addison**
  - IAPWS PCC Chair
  - NZAPWS Chair
  - Principal Consultant – Thermal Chemistry Limited
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  - + 64 21 843 762

INTERNATIONAL ASSOCIATION FOR THE PROPERTIES OF WATER & STEAM

IAPWS Objectives

The objectives of the Association are to advance the knowledge of the properties of water, steam and aqueous systems, particularly those properties and guidance of industrial importance, and to make the knowledge freely available to engineers and scientists the world over.

INTERNATIONAL ASSOCIATION FOR THE PROPERTIES OF WATER & STEAM

IAPWS Since 1929

IAPWS is an association of national organizations
Managed by an Executive Committee.
Meets annually—Everybody is invited
It's not a club or a membership.
International Conferences (ICPWS)
Are held every 4 or 5 years.
Working Meetings every year

Welcome from Members of IAPWS

POWER CYCLE CHEMISTRY WORKING GROUP (PCC WG)

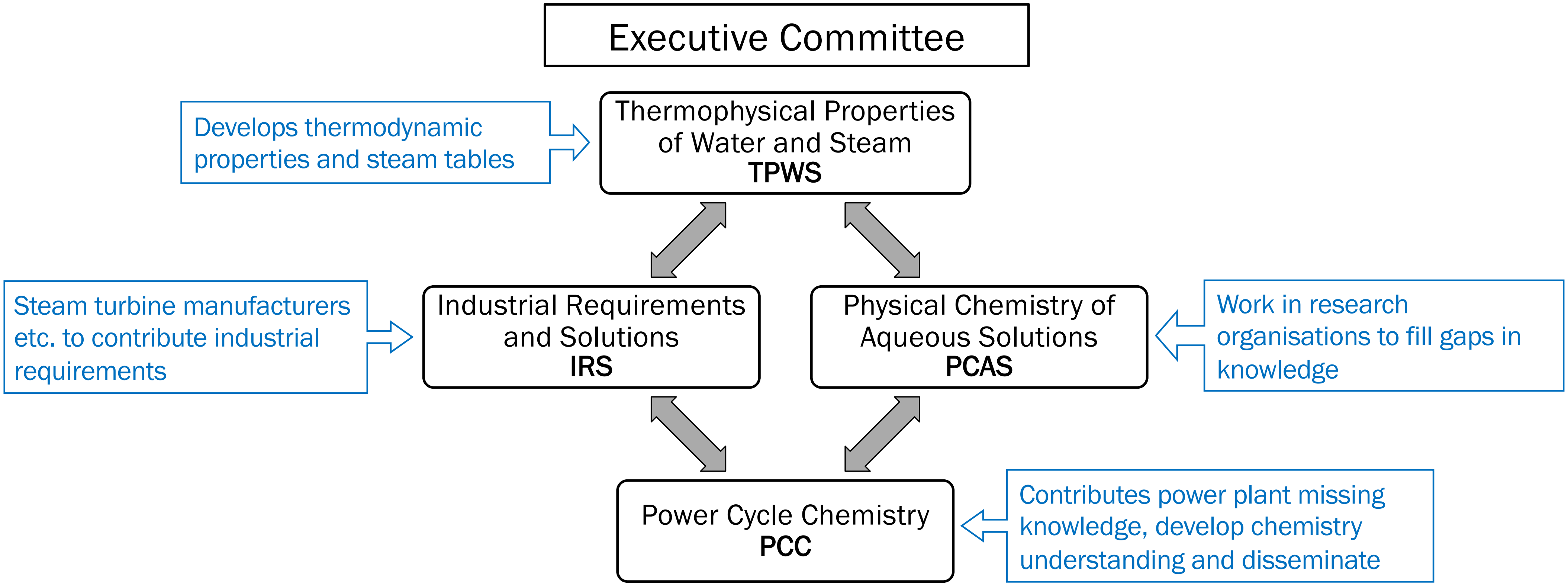
Countries or neighbouring countries

- **Members**
  - Australia
  - Canada
  - Germany & Switzerland
  - New Zealand
  - USA
  - Nordic [Denmark, Finland, Norway, Sweden]
  - BIAPWS [Britain and Ireland]
  - Czech Republic
  - Japan
  - ~~(Russia (suspended)~~

- **Associate Members**
  - Argentina and Brazil
  - Egypt
  - Greece
  - Israel
  - Netherlands (new in 2024)
  - China
  - France
  - India
  - Italy

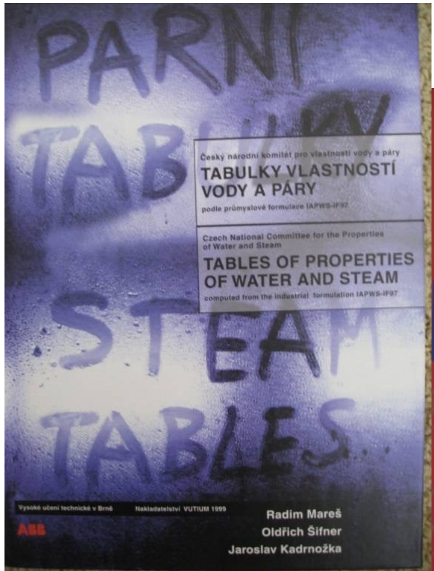
IAPWS Working Groups

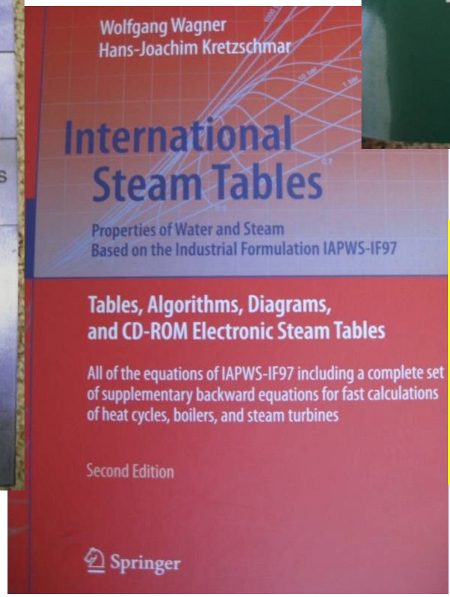
POWER CYCLE CHEMISTRY WORKING GROUP (PCC WG)

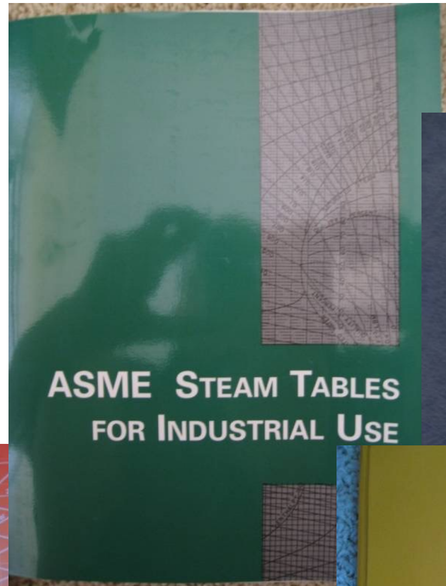


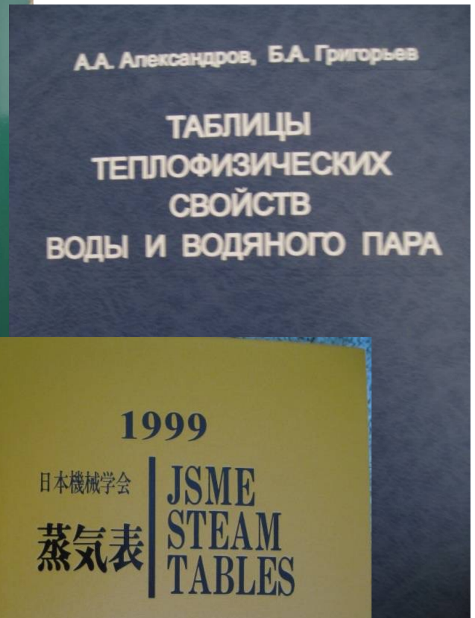
IAPWS International Penetration

IAPWS IF-97 and the Steam Tables around the World

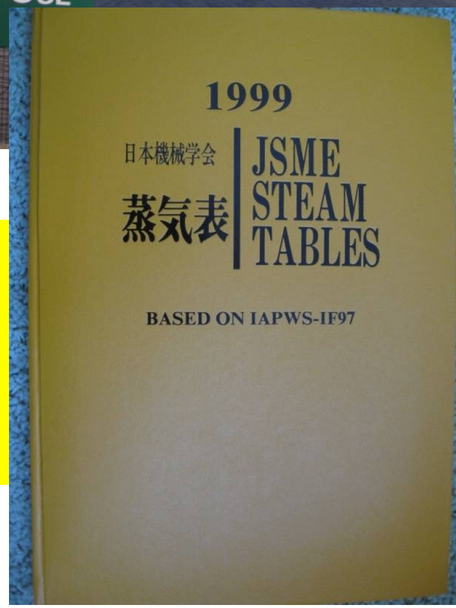








The basis of every power plant worldwide



POWER CYCLE CHEMISTRY WORKING GROUP (PCC WG)

Power Cycle Chemistry – Current Chairs
https://iapws.org/working-groups/PCC

David Addison (New Zealand)

PCC Chair - david.addison@thermalchemistry.com

Paul McCann (UK)

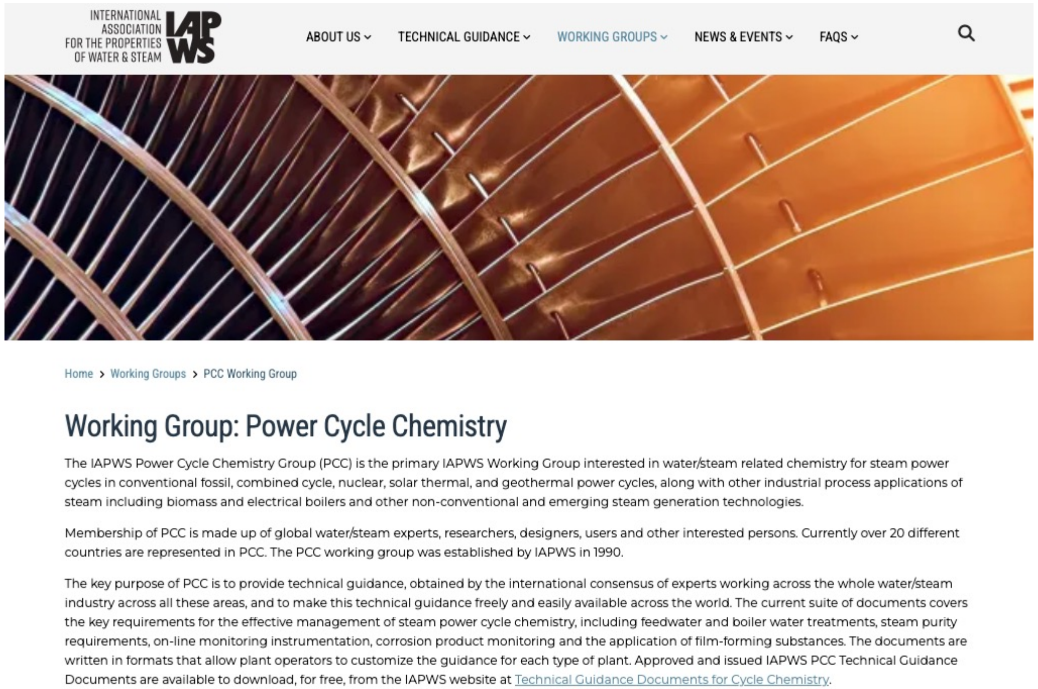
PCC Vice Chair - Paul.McCann@rwe.com

Kirk Buecher (USA)

PCC Vice Chair - Kirk.Buecher@mt.com

Taro Ichihara (Japan)

PCC Vice Chair - taro.ichihara.jp@mhi.com



POWER CYCLE CHEMISTRY WORKING GROUP (PCC WG)

Current Technical Guidance Documents – Free to Access

https://iapws.org/documents/techguide

Plus IAPWS PCC White Papers and past Webinars – on the IAPWS PCC Webpage (and YouTube)

https://iapws.org/working-groups/PCC

Next IAPWS PCC Webinar on Steam Chemistry/Phase Transition Zone – planned for March 2026 - TBA

PCC Webinars

The PCC working group is producing a series of webinars on water/steam chemistry for fossil and combined cycle plants and industrial steam plants to support chemists, engineers, operators, managers, students, etc. The recordings and presentations are available on the webinar page.

Webinars

PCC White Papers

White Paper on Corrosion Product Sampling, Monitoring and Analysis for Flexible and Fast Starting Plants
January 2025 revision

INTERNATIONAL ASSOCIATION FOR THE PROPERTIES OF WATER & STEAM IAPWS

ABOUT US | TECHNICAL GUIDANCE | WORKING GROUPS | NEWS & EVENTS | FAQS

Home > Technical Guidance > Technical Guidance Documents

IAPWS Technical Guidance Documents

Cycle Chemistry Guidelines for Fossil and Combined Cycle Plants

Cycle chemistry guidelines in the form of Technical Guidance Documents have been developed by IAPWS to provide truly international cycle chemistry guidance for fossil and combined cycle plants. They represent the accumulated experience of members of the IAPWS Power Cycle Chemistry (PCC) Working Group with expertise from 21 countries.

All current IAPWS Technical Guidance Documents are listed and described below and are downloadable as PDF files.

Application of Film Forming Substances in Industrial Steam Generators
Identifier: TGD11-19
Year of last revision: 2019
Description: Guidelines and Processes for the application of film forming substances (FFS) in industrial steam generation.
View document

Chemistry Management in Generator Water Cooling during Operation and Shutdown
Identifier: TGD10-19
Year of last revision: 2019
Description: Guidelines for cooling water chemistry during operation and layup for water-cooled generators.
View document

Air In-leakage in Steam-Water Cycles
Identifier: TGD9-18
Year of last revision: 2018
Description: Guidelines on the detection and measurement of air in-leakage (AIL) in reference to the optimum cycle chemistry control and maximum thermal cycle efficiency in a wide range of generating plants. Contains special guidance on how plant operators can recognize and control AIL.
View document

Application of Film Forming Substances in Fossil, Combined Cycle, and Biomass Power Plants
Identifier: TGD8-16(2019)
Year of last revision: 2019
Description: Cycle Chemistry Guidelines and Processes for the application of film forming amines (FFA) and Film Forming Amine Products (FFAP) in fossil and combined cycle / HRSG power plants.
View document

HRSG High Pressure Evaporator Sampling for Internal Deposit Identification and Determining the Need to Chemical Clean
Identifier: TGD7-16

International Meetings / Conferences

POWER CYCLE CHEMISTRY WORKING GROUP (PCC WG)

2026 Bookmarks:

IAPWS 2025 Annual Meeting - https://iapws.org/news-and-events/meetings

Bristol, UK.

28th June – 3rd July 2026

The premier international annual meeting on all aspects of water/steam including cycle chemistry

Home > News & Events > IAPWS Annual Meetings > 2026 IAPWS Annual Meeting

2026 IAPWS Annual Meeting:

28 Jun 2026 to 3 Jul 2026

Bristol Hotel, Bristol, England

For more info, click here

The 2026 IAPWS Annual Meeting will be held at the Bristol Hotel in Bristol, England from 28 June to 3 July 2026. Detailed information, including meeting agendas, registration material, information on accommodations, etc., will be posted on the conference website, IAPWS2026.com, as it becomes available.

As usual, Executive Committee meetings, Working Group meetings, Award presentations, and a locally-organized Symposium will be held as parts of the IAPWS Annual Meeting.

The Britain and Ireland National Committee is hosting the meeting, and provides the website IAPWS2026.com. The website will be updated as additional information becomes available.

International Meetings / Conferences

2026 Bookmarks:

Note: These are not official IAPWS Supported Events but of major interest to HRSG Operators as they will contain the latest IAPWS information on FAC, FFS and avoiding internal HP Evaporator Deposits

European HRSG Forum (EHF2026)

19-21 May 2026. Monash University, Prato, Italy
Chairs: Bob Anderson and Barry Dooley
Organizer: Scott Schwieger, CCJ
https://europeanhrsgforum.com

European Hrsg Forum
www.europeanHRSGforum.com

HRSG Forum (HF2026)

20-23 July 2026. The Woodlands, Texas, USA
Chairs: Bob Anderson and Barry Dooley
Organizer: Scott Schwieger, CCJ
https://hrsgforum.com/

HRSG FORUM

IAPWS

International Meetings / Conferences

2026 Bookmarks:

8th IAPWS ABHUG

(Australasian Boiler/HRSG Users Group)

Brisbane, Australia. November 2026 (dates TBC)

Premier Boiler / HRSG / Chemistry Event in antipodes

Chairs: Barry Dooley and Bob Anderson
Organizers: Mecca Concepts, Australia.
https://abhug.com

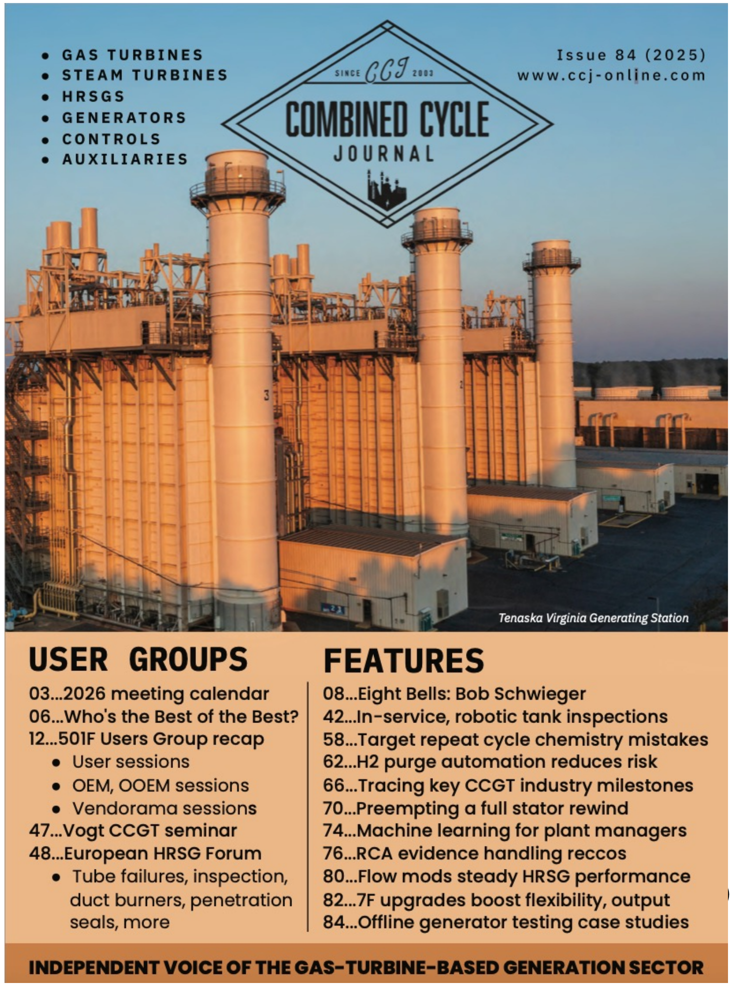
Plus local IAPWS National Committee Events in 2026 and 2027 – check your local IAPWS websites – e.g.

- **Dutch IAPWS meeting – 3-4 March**
- **German/Swiss IAPWS meeting – 5-6 March**
- **New Zealand IAPWS meeting – 7-9 September**

Combined Cycle Journal

- Massive thank you to Combined Cycle Journal for hosting the Webinar for us!

- https://www.ccj-online.com



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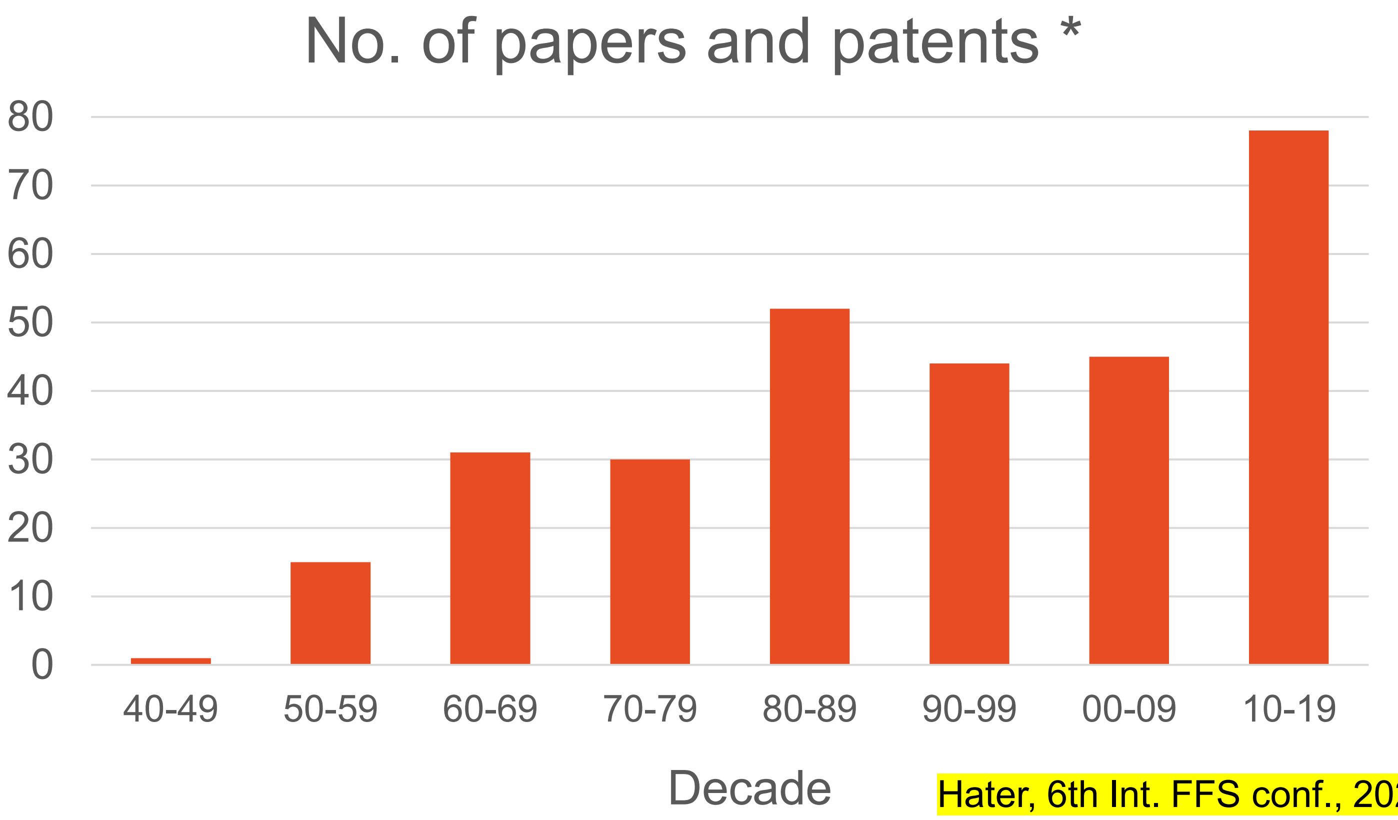
POWER CYCLE CHEMISTRY WORKING GROUP (PCC WG)

The Application of Film Forming Substances (FFS) in Power Cycles

"The biggest and most important addition to cycle chemistry control worldwide since OT in 1990, but not enough scientific background and understanding"

Barry Dooley – Structural Integrity, UK
Wolfgang Hater – H_2O Training & Consulting, Germany

Research on Film Forming Substances



Hater, 6th Int. FFS conf., 2023

* Conference contributions not included

Applications in water treatment

Cooling systems
- Closed circuits
- Open circuits

Geothermal

Power cycle

Predominantly research has been on FFA!

Technical Guidance Documents

11 comprehensive documents summarizing the state of knowledge of power cycle chemistry

Freely available from IAPWS (https://iapws.org/documents/techguide)

First internationally accepted documents on Film Forming Substances

- TGD11-19 Application of Film Forming Substances in Industrial Steam Generators
- TGD8-16(2019) Application of Film Forming Substances in Fossil, Combined Cycle, and Biomass Power Plants
- IAPWS Certified Research Need 33 on FFS. Final Draft November 2025.

Important activities on FFS

Seven IAPWS International Conferences on Film Forming Substances

(Chairs: B. Dooley and D. Addison)

and

Numerous Plant Assessments and Application Assistances Worldwide

What is a Film Forming Substance?

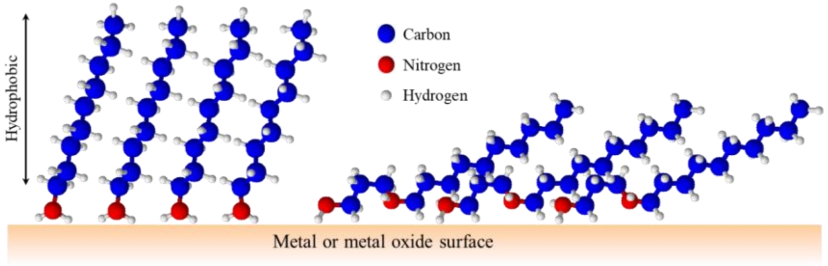
- Online and offline corrosion inhibitor by adsorption onto metal/metal oxide surfaces

- Application
  - supplemental to a base cycle chemistry program – (IAPWS suggests optimised base chemistry program first)
  - full treatment program (blended with other components)

- Organic molecule – usually consisting of carbon/hydrogen/nitrogen/oxygen

- Soluble in the water/steam cycle at low concentrations

- Steam volatility depending on molecule



Quick Reminder of International FFS Nomenclature

Film Forming Substances (FFS)

(Molecule, Commercial product)

FFA/FFAP | **FFP**

<u>Film Forming Amines (FFA)</u>
- Octadecylamine – ODA
- Oleyamine – OLA
- Oleyl Propylenediamine – OLDA

<u>Film Forming Products (FFP)</u>
Proprietary and non-disclosed

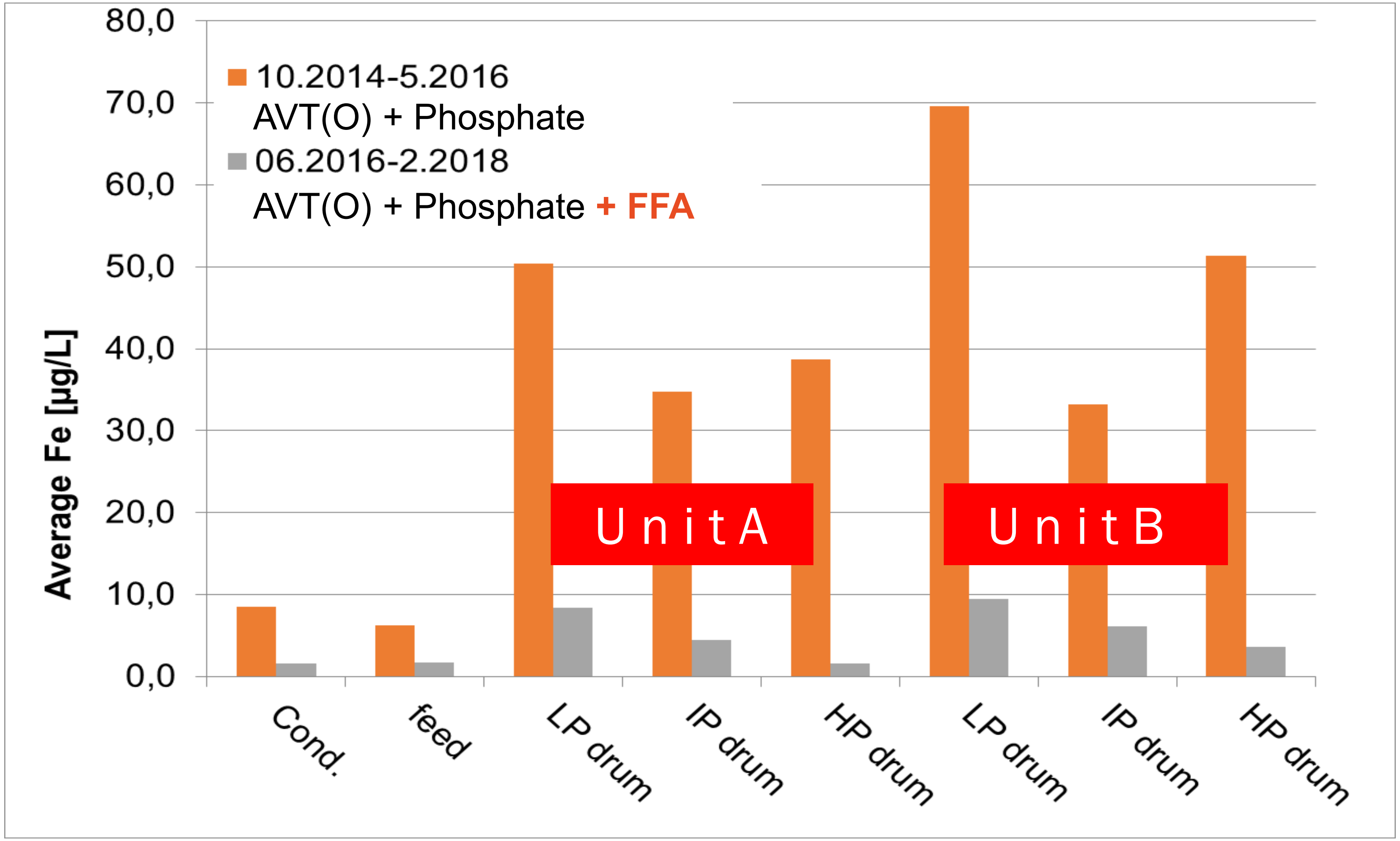
IAPWS Technical Guidance Documents for FFS
Freely available and downloadable on the IAPWS website www.IAPWS.org

Major Motivation for the Application of an FFS preferred on top of established IAPWS operating chemistries (AVT, OT, PT and CT)

- Reduction of Fe and Cu levels in Water/Steam Cycle
- Improved shutdown protection
- Energy efficiency improvement
- Improved plant cleanliness
- Faster start-up after shutdown

Cycle chemistry should be optimised before applying FFS

Reduction of Fe and Cu Levels to below IAPWS Guidance



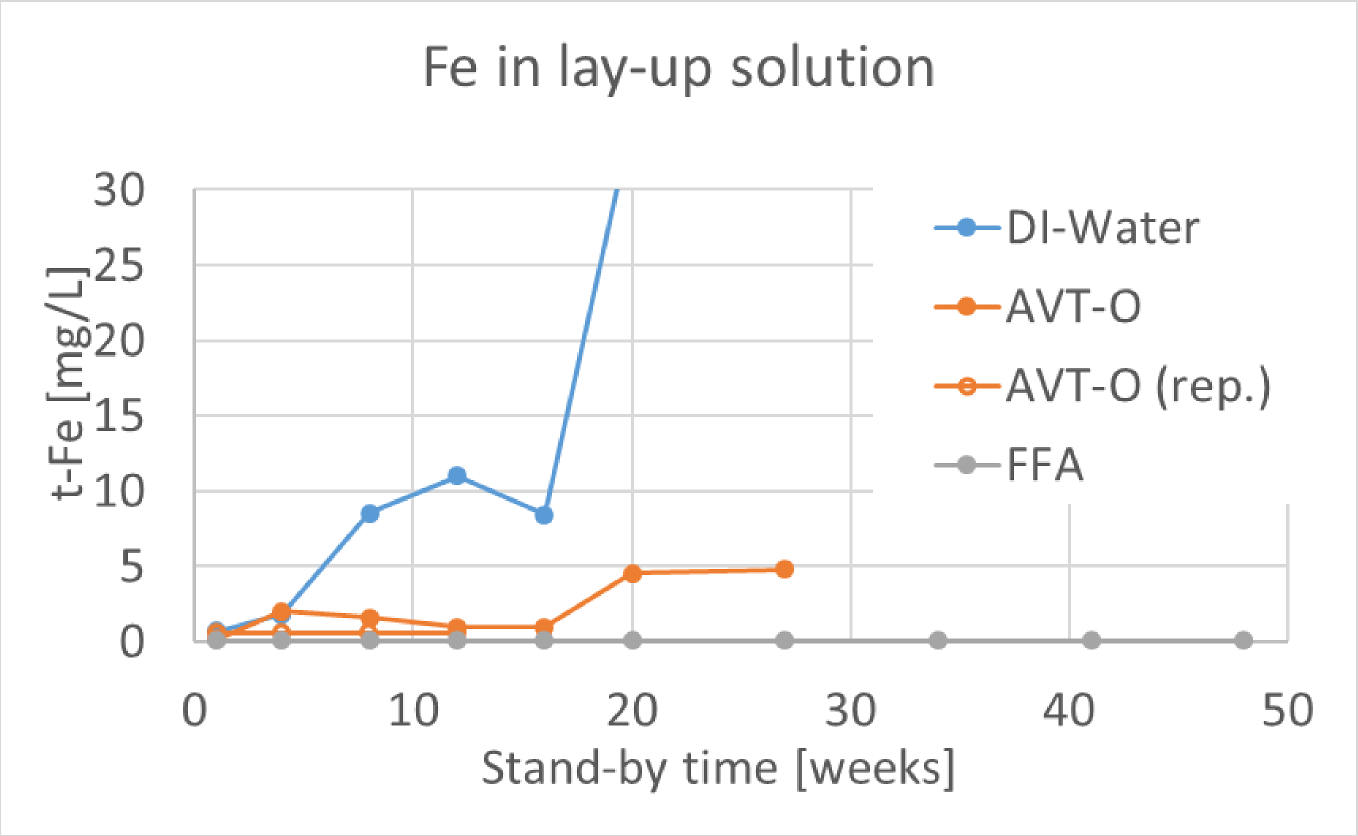
Leagas et.al., 6th EHF., 2019

Data from
CCGT plant

(Cycling mode)

Improved Shutdown Protection

Hater et.al., PPChem 2014 16,5



Hater IAPWS meeting 2019

Feedwater tank of a CHP Plant during shutdown inspection
(Systems treated with FFA and emptied)

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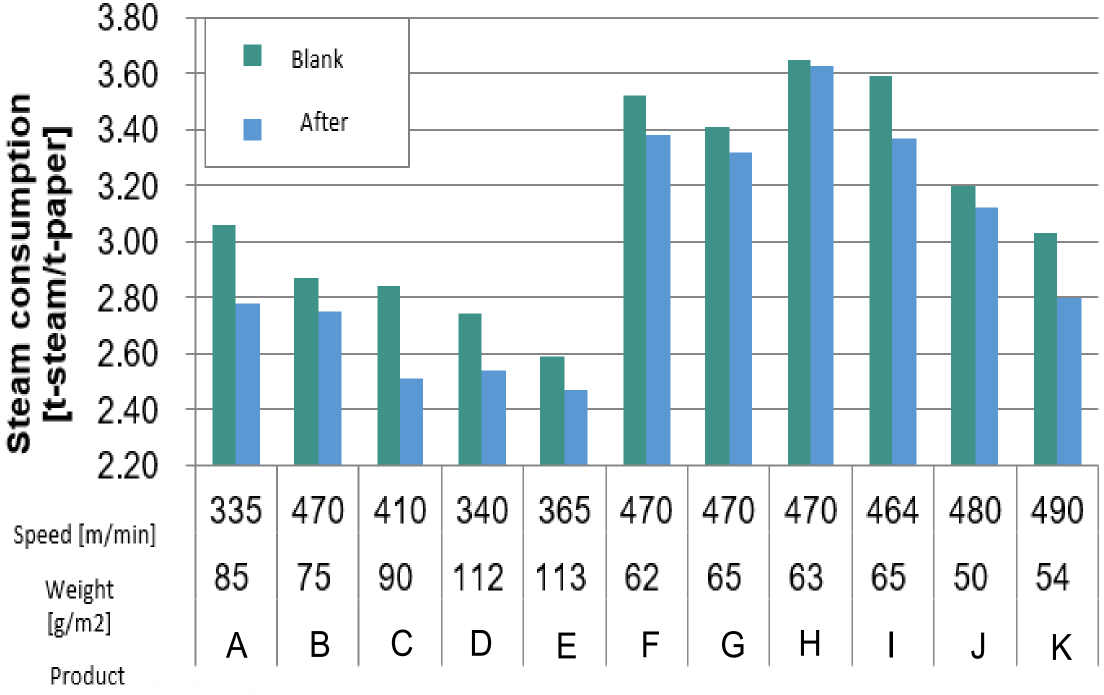
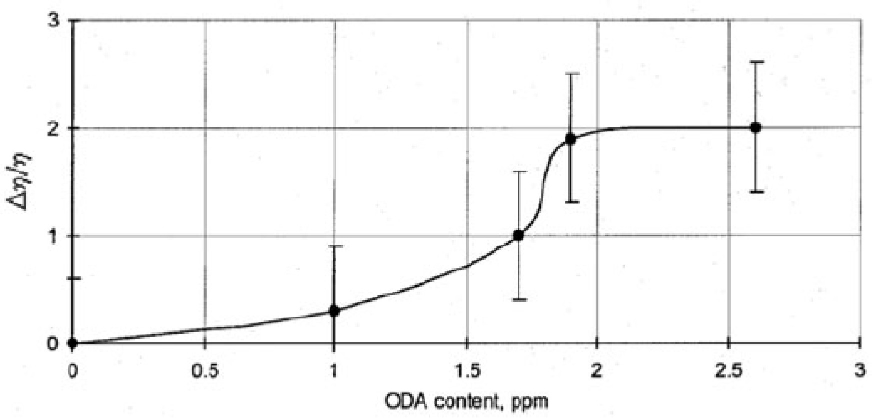
Energy Efficiency Improvement

IWC 2020, paper 20-26



Improvement of heat transfer by FFS in condensers (paper mills)

Turbine Efficiency vs ODA Concentration in Steam

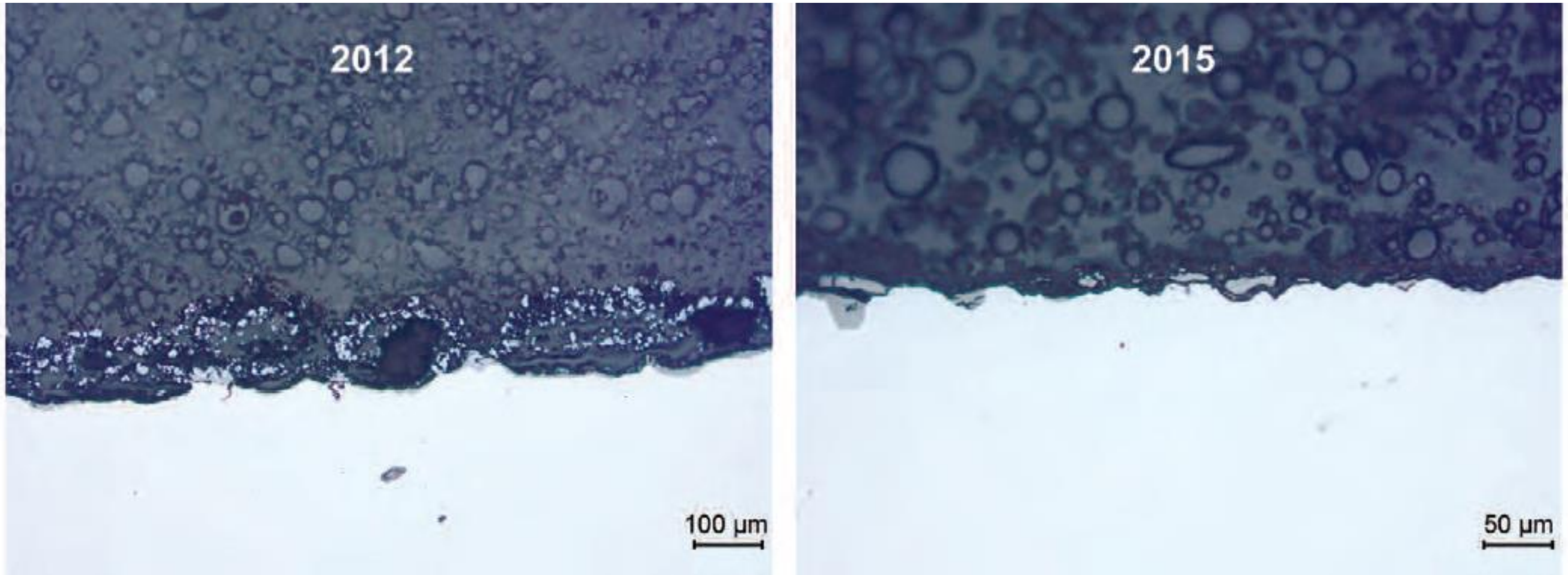


Increase in ODA level in the inlet turbine steam from 0 to 2.6 ppm resulted in ~2% increase in turbine efficiency

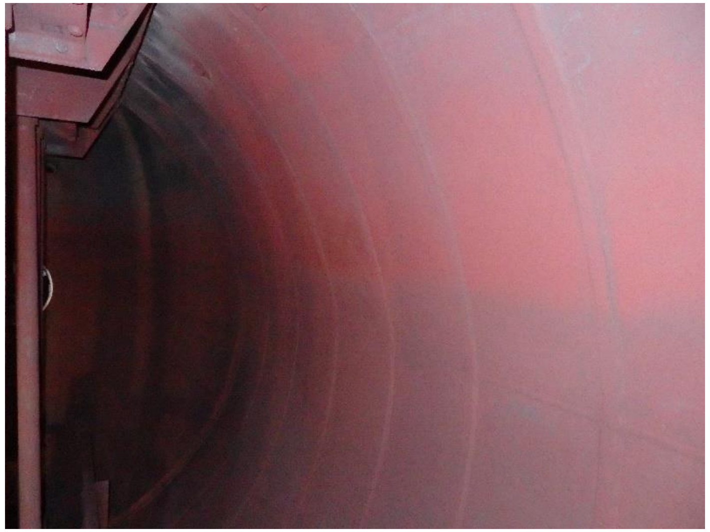
Tests at the Moscow Power Institute (Petrova and Dooley)

Improved Plant Cleanliness

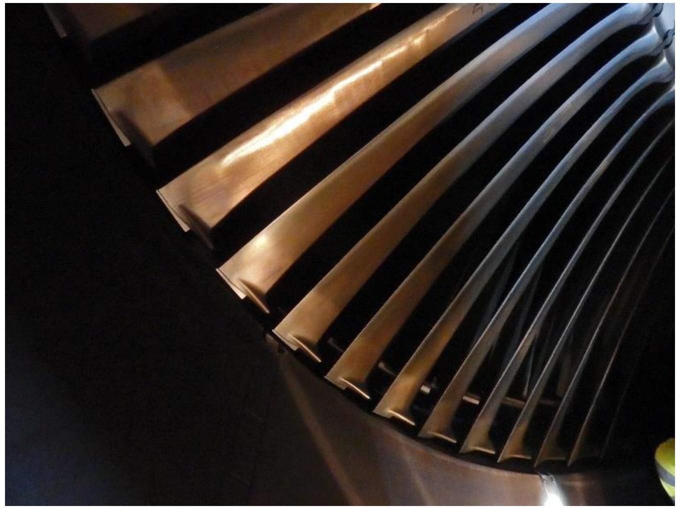
Hater et.al. PPChem 2018 20,3



Removal of loose iron
Oxide from HP evaporator
tubes by FFA



IP
drum



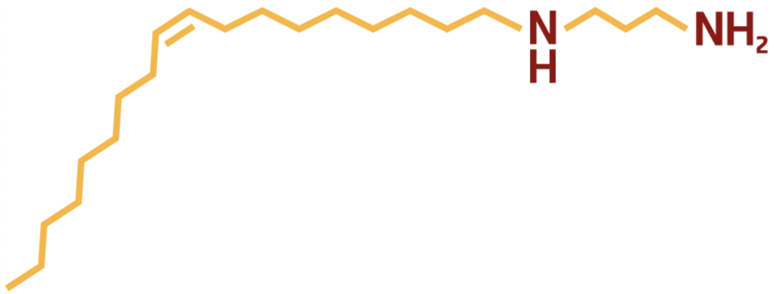
LP
turbine

Film Forming Amines (FFA)

- **Octadecylamine (ODA)**
  $CH_3(CH_2)_{16}CH_2NH_2$ or $C_{18}H_{37}NH_2$

- **Oleyamine (OLA)**
  $CH_3(CH_2)_7CH{=}CH(CH_2)_7CH_2NH_2$or $C_{18}H_{35}NH_2$

- **Oleyl Propylenediamine (OLDA)**
  $CH_3(CH_2)_7CH{=}CH(CH_2)_8NHCH_2CH_2CH_2NH_2$
  or $C_{21}\ H_{44}\ N_2$



- NH_2 group is polar end for all molecules
  - End that bonds to the surface via N atom/π electrons

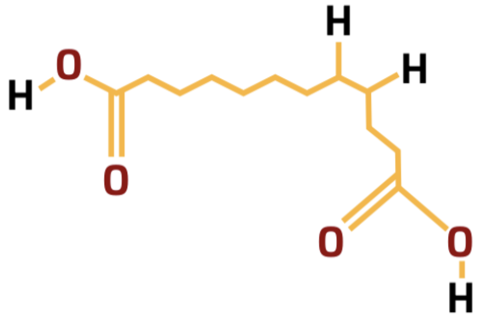
Film Forming Products (FFP)

- Likely dicarboxylic acids and derivates, e.g. with amide groups

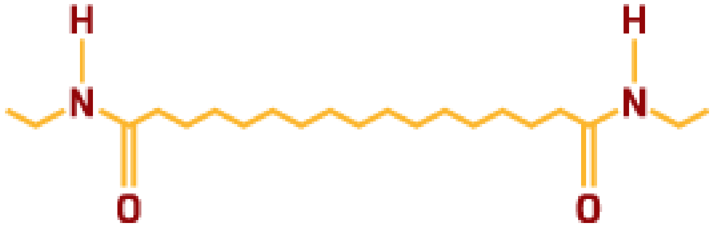
Literature examples (updated for 2025) include

- Dodecanedioic Acid (DDDA)
- cis-4-decendionic acid
- *N*¹,*N*⁹-Diethylnonanediamide (amide)
- Nonanedioic (azelaic) acid (also azelaic acid dihydrazide)
- Sorbitol fatty acid ester
- N,N'-distrayl adipamide
- Ethylene bis-Stearamide
- Other fatty amines

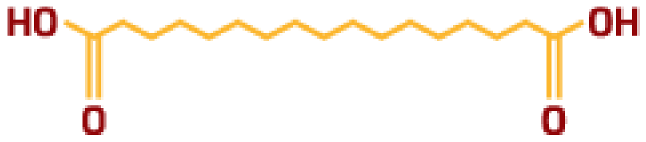
Dodecanedioic Acid (DDDA)



cis-4-decendionic acid

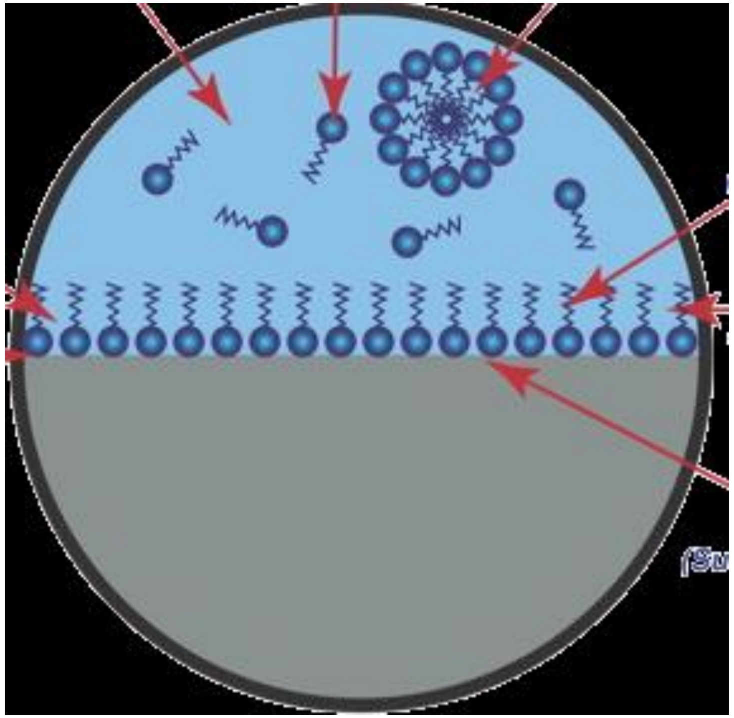


*N*¹, *N*⁹ - Diethylnonanediamide



Nonanedioic (azelaic) acid

Some Background on FFS Mode of Action



Rob Lindsay: Film Forming Corrosion Inhibitors: Key Interfacial Insights with Photoelectron Spectroscopy – 5th International conference on FFS, 2022

FFS are surface active molecules
3 different species (different behaviour):
- Freely dissolved molecules
- Micelles (above CMC)
  (CMC: Critical Micelle Concentration)
- Adsorbed molecules (on surface)

Hydrophobic film has been thought to "protect" the steel by decreasing contact between water/metal

Wide Range of Commercial Products and Suppliers

Two main groups of commercial products

- Filming components (FFA or non-disclosed (FFP)) + (emulsifyer)

  (mainly supplemental to base chemistry program)

- Filming components (FFA or non-disclosed (FFP)) + (emulsifyer)

  + Alkalising agents

    alkalising amines

    NaOH, phosphate

  [+dispersing agents (polycarboxlyate)

  + reducing agents]

  (often as full cycle chemistry program)

Operator should know composition of applied product
Variety of components and formulations difficult for common research

FFS Analytics (free residual in water)

- FFA

  as cationic surfactant

  with a selective Xanthan dye (mainly Bengalrose)

Grab samples

  Test-kits

  Photometrically (reagents commercially available)

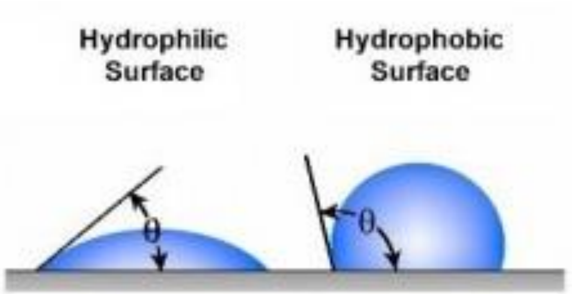
Automated Bengalrose method

Indirect measurement via test specimen in WSC

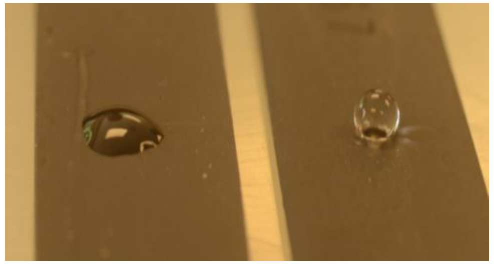
- FFP (vendor methods)

Parameters that include multiple groups of chemicals (e.g. COD, TOC etc) are not suitable!!

Analytics (on surfaces)



- Hydrophobicity/contact angle
  - commonly used, but non „standardized“
  - non specific for filmer
  - false positive **and** false negative possible
  - correlation with protection level not clear

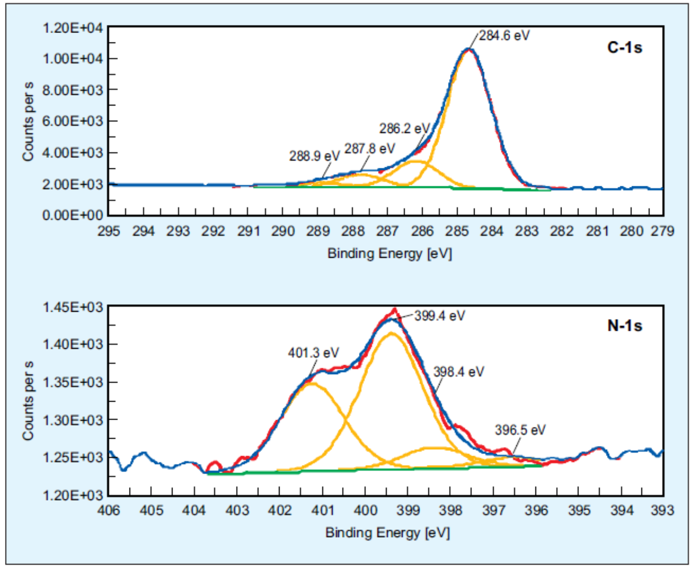


- Semi-quantative wipe-test with solvent (on-site)

  -> determination of FFA with Bengalrose

- Sophisticated surface analytics (off-site)

  e.g. XPS, IR



Smith et.al. PPChem 2017 19,3

FFS Decomposition

All film forming molecules are organic and face partial decomposition

- FFA:

  well studied and understood

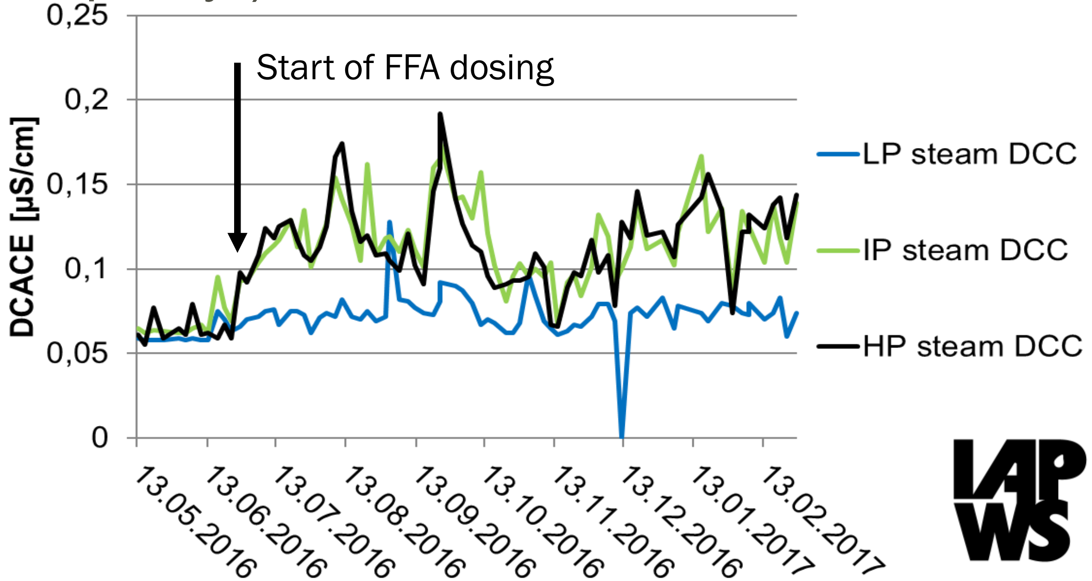
  main decomposition products:

  Ammonia,

  LMWA (mainly acetic acid, formic acid)

  certain increase of CACE (steam purity!)

Leagas et.al., 6th EHF., 2019



- FFP molecules:

  almost no studies published

Particle Transport

- Oppositional effects observed when using filming molecules
  - Cleaning effect, i.e. removal of porous oxides
    dispersing effect
  - Formation of deposits („Gunk balls“)
    clogging effect

Janssen et.al. PPChem 2012 14,7

risk of deposit formation & UDC increases with
increasing internal deposits
increasing filmer dosage

High Importance of
- **Assessment of internal deposits and eventually cleaning**
- **careful dosage and dosage control of filmer**

Dosage & Monitoring

- Continuous dosage automatically controlled by feed water or condensate flow preferred into

  - Condensate (cond. pump discharge or cond. polisher outlet)

    or

  - Feed water pump inlet

  In case of non-volatile components dosage after the branch of spray water!
- Single dosing point generally enough
- Check material compatibility (seals, membranes etc.)
- Often initially lower dosage; **avoid overdosage**

- Monitoring: normal parameters according to IAPWS TGDs

  + FFS residual in water

Preparation and Review before FFS Application

Chapter 8 of TGDs recommendations

- Comprehensive assessment of plant status and possible risks
- Definition of targets for improvement
- Training of plant people
- Base line determination of current cycle chemistry.
  - **- Corrosion products and internal deposits (covered later)**
  - **- Plant efficiency**
  - **- …**
- After changeover to FFS treatment validation of target achievement, reassessment of plant status

Without proper baseline determination no evaluation of success is possible

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Recommendations for Change between different FFS

- FFS dosage supplemental to IAPWS base chemistry program

  - stop dosage of current FFS
  - clean dosing system
  - operate system a couple of days without FFS dosage
  - start dosage of new FFS

  - Mixing of commercial products in storage vessel not recommended

- In case of full cycle chemistry FFS product a case by case evaluation is needed

End of Part One of FFS Webinar

INTERNATIONAL ASSOCIATION FOR THE PROPERTIES OF WATER & STEAM

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1

The Application of Film Forming Substances (FFS) in Power Cycles

"The biggest and most important addition to cycle chemistry control worldwide since OT in 1990, but not enough scientific background and understanding"

Barry Dooley – Structural Integrity, UK
Wolfgang Hater – H_2O Training & Consulting, Germany

Part 2

IAPWS

2

Some Summary Key Highlights from Fossil and Combined Cycle/HRSG FFS Applications

- Universal reductions in feedwater Fe and Cu transport but no equivalent understanding of the mechanism of oxide growth reductions
- General observations of hydrophobic films on water-touched surfaces, but it is underlined that hydrophobicity (contact angle) does not prove presence of a film or any protection
- Generally good shutdown protection of water-touched surfaces
- But film formation and protection remain very questionable on steam-touched surfaces
- Adsorption of film onto metal (oxide ?) surfaces as a function of FFS will provide information for changing the FFS applied
- Arresting local FAC is difficult to "see" other than by reduction of Fe. Some ACC corrosion / FAC is the exception (IAPWS Decay Map to be used)
- Problems occurring in plants worldwide (but not openly published)(see examples): internal deposits, tube failures especially UDC (maybe new), formation of "gunk" (gel-like) deposits in drums and on heat transfer surfaces, in steam turbines, and strainers/filters

See a few examples of many analyzed

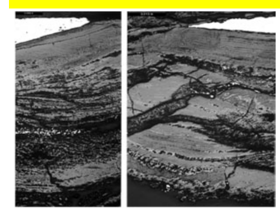
IAPWS

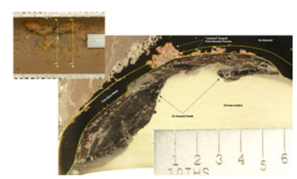
3

HP Evaporator Heavy Deposits and Failure

Double Pressure HRSG (9 and 0.5 MPa). HTF after FFS Application without thorough upfront review (such as IAPWS Section 8)

Severe Under-deposit Corrosion (UDC)* in typical multi-laminated morphology. But no material degradation (voids)





* Perhaps a new HTF variant*

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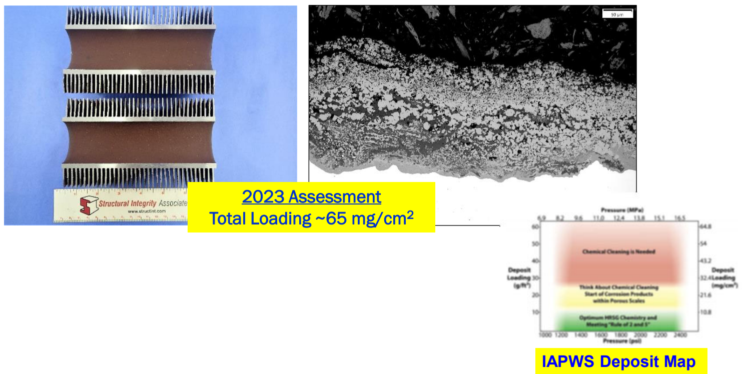
4

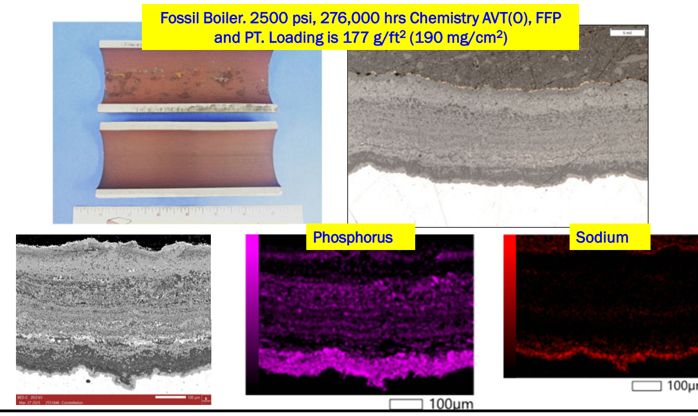
Please do not add FFS if your HP Evaporator looks like this and/or has corrosion reaction products

(use the IAPWS Deposit Map to make an assessment)



5

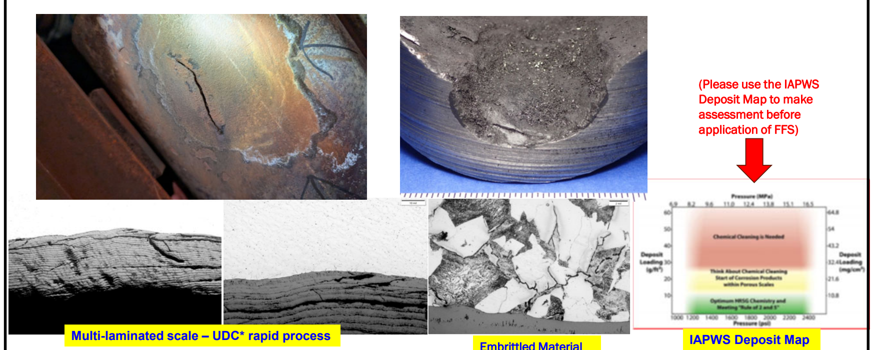
Beware of Increasing Fossil Waterwall Deposits after FFS Application (without detailed up-front Section 8 FFS TGD review)



6

or you might end up with an HP Evaporator like this

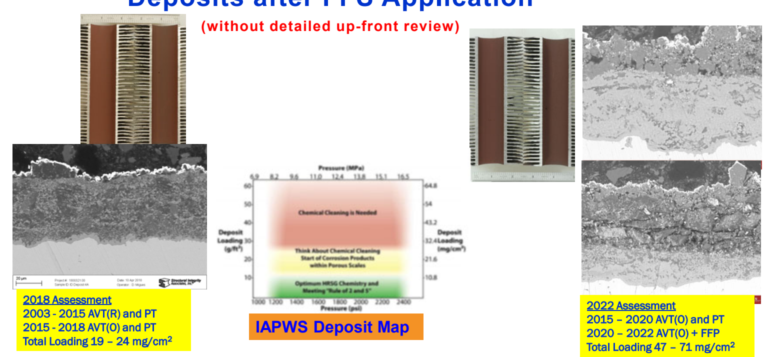
(2x1 Triple Pressure HRSG, Operating on AVT(O) with FFA (polyamine) added)



7

Beware of Increasing HP Evaporator Deposits after FFS Application

(without detailed up-front review)



8

LP Drum Deposits

Triple Pressure HRSG. Gunk formation in LP Drum with no IAPWS Section 8 Review Before Application

FTIR of gunk deposits indicated the presence of hydrocarbon and functional groups of carbonyl or carboxylic acid.

9

ACC Two-phase FAC can be "Arrested" with FFS

(Example of Significant Reduction in DHACI for FAC at Tube Entries in ACC. Accompanied by Significant Reduction of Total Iron in Condensate. But many cases where FFA and FFP have not "arrested" ACC FAC)

Cross member appear to arrest using FFS

Source: DHACI ACCUG Guideline

For ACC the FAC / Corrosion damage is the same worldwide with all chemistries and plant types (Based on assessment / inspection work conducted in Australia, Canada, Chile, China, Cote d'Ivoire, Dubai, India, Ireland, Mexico, Qatar, Abu Dhabi, UAE, South Africa, Trinidad, UK and US)

10

Key IAPWS Tools for Conducting a "Section 8" Review

- Monitoring total iron: simple "Achievable Level" Table for steady load units. (IAPWS TGD 6-13, 2014)
- Monitoring total iron in flexibly operated plant: decay map and profile. (IAPWS PCC 24-001, January 2025)
- Monitoring HRSG HP Evap internal deposits. (IAPWS TGD 7-16, 2016)

11

Sampling and Analysis of Corrosion Products

Non- Suitable methods

* Spectrophotometer in lab or using Millipore filters

Suitable methods

- Sampling and locations
- Post sample digestion UV-Vis (Ferrozine) with a 5 cm cell - Fe only
- Graphite Furnace Atomic Absorption spectrometry (GF-AA) post sample digestion
- Inductively coupled plasma mass spectrometry (ICP-MS) post sample digestion

Key points are:

1. Full digestion for all samples required
2. Detection limit of < 2 μg/kg required (lower the DL the better)

IAPWS TGD 6-13, September 2014

12

Achievable Total Fe (& Cu) Levels
Different Plant Types/Optimized Chemistry
Steady/Base Loaded Plants

Feedwater

OT:	Total Fe =	< 1 µg/kg
AVT:	Total Fe =	< 2 µg/kg
AVT (Mixed):	Total Fe & Cu =	< 2 µg/kg
HP/LP Heater Drains:	Total Fe & Cu =	< 1 µg/kg

HRSG Evaporators/Drums

AVT/PT/CT:	Total Fe =	< 5 µg/kg

Units with Air-Cooled Condenser (ACC)

ACC Outlet:	Total Fe =	< 10 µg/kg
Post Condensate Filter:	Total Fe =	< 5 µg/kg

Cogeneration / Industrial Plants

Condensate Return:	Total Fe =	< 10 µg/kg

IAPWS TGD 6-13, September 2014

Higher than these values indicates a Repeat Cycle Chemistry Situation (RCCS)

13

New IAPWS Procedure to Quantify CP Transport During Startup

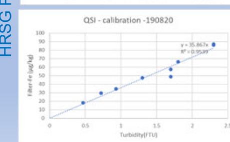
For Fast Start or Frequently Started Plants the important Corrosion Product Indicator is how quickly the Fe decay takes place from the high shutdown level during startup. This can be monitored by using Proxy Analysis for Total Iron (turbidity) and overlaying the decay profile on IAPWS Decay Map

- **Summary of procedure**
  - **Flush feedwater sample point as soon as pressure is available**
  - **Measure and register oxide levels in feedwater by proxy methods during startup**
  - **Take samples for filtered iron intermittently to establish correlation to proxy results**
  - **Note times for milestones: First fire, by-pass, turbine roll-up, synchronisation etc.**
  - **Plot iron levels versus time after First fire, mark milestones**
  - **Integrate (iron level * feedwater flow) from First fire to steady-state level → iron transported to boiler during startup**

Example: Startup of a Well Operated HRSG Plant

101	GT fire
102	FWT heating
103	Make-up
104	ST sync

Iron transported: 4.3 g

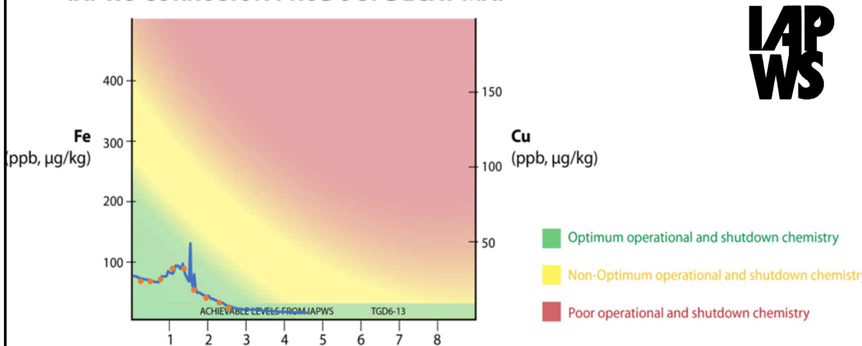


Combined Cycle/HRSG. AVT(O) feedwater. Dry air preservation.

IAPWS White Paper, January 2025

14

IAPWS CORROSION PRODUCT DECAY MAP



Decay Profile for well operated combined cycle/HRSG plant is superimposed. AVT(O). Dry air preservation of boiler

Guidance is provided in Section 7 of White Paper. The goals for each plant should be for the profile to be in the Green Area with short times to reach achievable levels. Zero time can be start of BFP, first fires, synchronization, pressure changes or other.

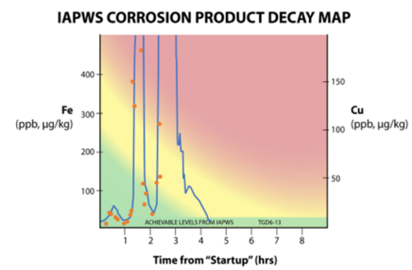
IAPWS White Paper, January 2025

15

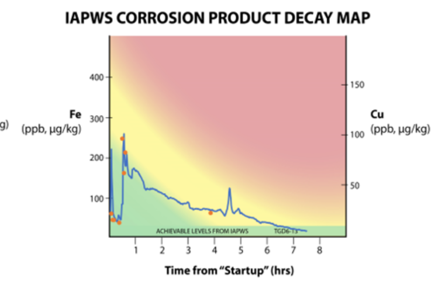
15

Examples from Plants that need to improve Operation and/or Shutdown Chemistries

(can easily be seen by superimposing on IAPWS Decay Map)



All-ferrous feedwater. Cu condenser. AVT(O). Daily load cycling. Startup in 60MW increments



All-ferrous feedwater. AVT(O). Summer shutdown with no protection.

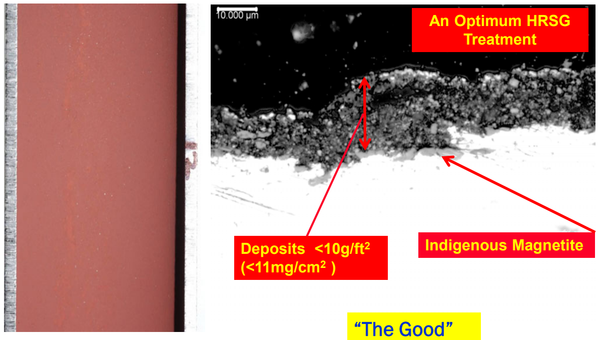
IAPWS White Paper, January 2025

Decay Profiles in the Red/Yellow indicate a Repeat Cycle Chemistry Situation (RCCS)

16

HP Evaporator 1800psi (12.4MPa). 16K hrs

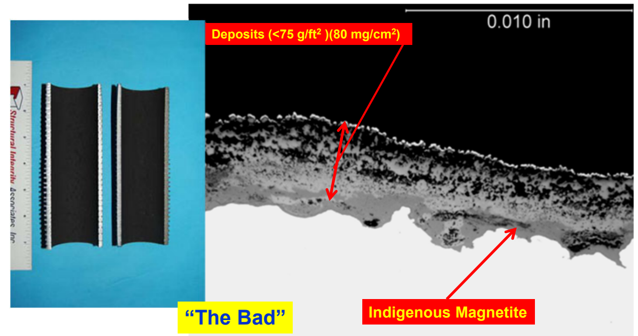
(AVT(O) with only ammonia in condensate, and only TSP in HP Evaporator at 2-5 ppm)



17

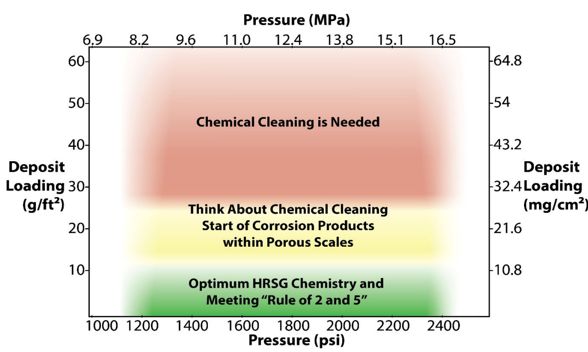
HP Evaporator 1820psi (12.5MPa)

(Non-optimum chemistry. AVT(R), neutralizing amine + reducing agent in feedwater, MSP/NaOH in Evaporator)



18

IAPWS Deposition Map for HRSG HP Evaporators



IAPWS TGD TGD7-16(2016)

Includes suggested location for sampling HP Evap Tube Samples: the lead tube about 1m down from header

Original: Dooley / Weiss PPChem 2010 (45)
Latest Data March 2025 (>150)

Deposits in Red are considered an RCCS. Don't apply an FFS.

19

Film Forming Substances Research and Application Needs

The following require more definitive results and/or research and will be focused in an IAPWS Certified Research Need (ICRN)

- Much work has been conducted on metal surfaces rather than oxide surfaces
- Needed fundamental/research work:
  - effect of FFS on growth mechanisms of Fe, Cu and Cr oxides in water & steam (major current deficiency- three examples originally provided)
  - effect of FFS on BTF/HTF (UDC and CF) and SCC
  - film formation, kinetics, structure and porosity on water- and steam-touched oxide surfaces
  - uncertainty of stability limit and decomposition products for all FFA and especially FFP
  - uncertainty of adsorption onto oxide surfaces as a function of FFS
  - and protection of superheated steam surfaces as a function of FFS
  - increased steam turbine performance for amine-based FFS (ODA) but what about other FFA and FFP (any change in surface tension?).
- Application work:
  - change of FFS (for example change from FFP to FFA)
  - use of FFS with increased levels of deposits

20

ICRN 33

IAPWS Certified Research Need – ICRN

Film Forming Substances in Water/Steam Cycles (Fossil, Nuclear, Industrial, and Geothermal Plants)

The IAPWS Power Cycle Chemistry Working Group is aware of increasing use in the boiler and steam industry of film forming substances (FFS) that are utilized as corrosion inhibitors within the water/steam cycle. However, there are a significant number of scientific unknowns related to the use of these compounds, their modes of operation in relation to corrosion inhibiting, and other properties such as influences on steam generating and steam condensing processes, physical properties, and application benefits.

When applied correctly, the use of FFS can have benefits for reducing corrosion in water/steam cycles, particularly improving wet and dry conservation during shutdown/layup. Equally, misapplication of FFS can result in poorly Performing applications where additional corrosion protection is not provided, the risk of plant damage/failure occurring is increased due to corrosion, and the applications are uneconomic in nature.

Currently in International IAPWS Member Review
To be published April 2026

21

A few concluding remarks:

- Well established and understood chemistries for > 30 yrs after much research
  - AVT(O), AVT(R), OT, PT and CT + PTZ Failure/Damage in ST
- FFS for last 15+ years have been applied without the same level of detailed basic understanding (no understanding of how an FFA or FFP changes the growth of oxide? Is there any fundamental difference between an FFA and an FFP in producing any results, Except on cost?)
- Big question is: “how do we change from one FFS to another?”
- In the interim before this understanding is more complete:
- Rule 1: make sure plant chemistry is optimized before application of an FFS (e.g.: monitor Iron; use IAPWS Decay Map and use Internal Deposit Map)
- Rule 2: conduct a comprehensive review before and after an FFS application (using the IAPWS Decay Map within an IAPWS TGD Section 8 Review)
- Rule 3: use IAPWS Decay Map to verify improvement of Fe-level

Discussion by Users

22

Thank you for your attention

We hope you have Questions and/or Comments

Please write in Chat.

Feel free to contact us at:

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23