Advanced AQCS Technology for Further Emission Control

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27 Nov., 2013 @ VGB-TENPES EXPERT MEETING

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1. Ultra Low PM Emission Control Using Gas Cooler
2. Mercury Removal Using Special Catalyst

1. Ultra Low PM Emission Control Using Gas Cooler

1.1 Typical Emission Trend in Japan (Coal-Fired)

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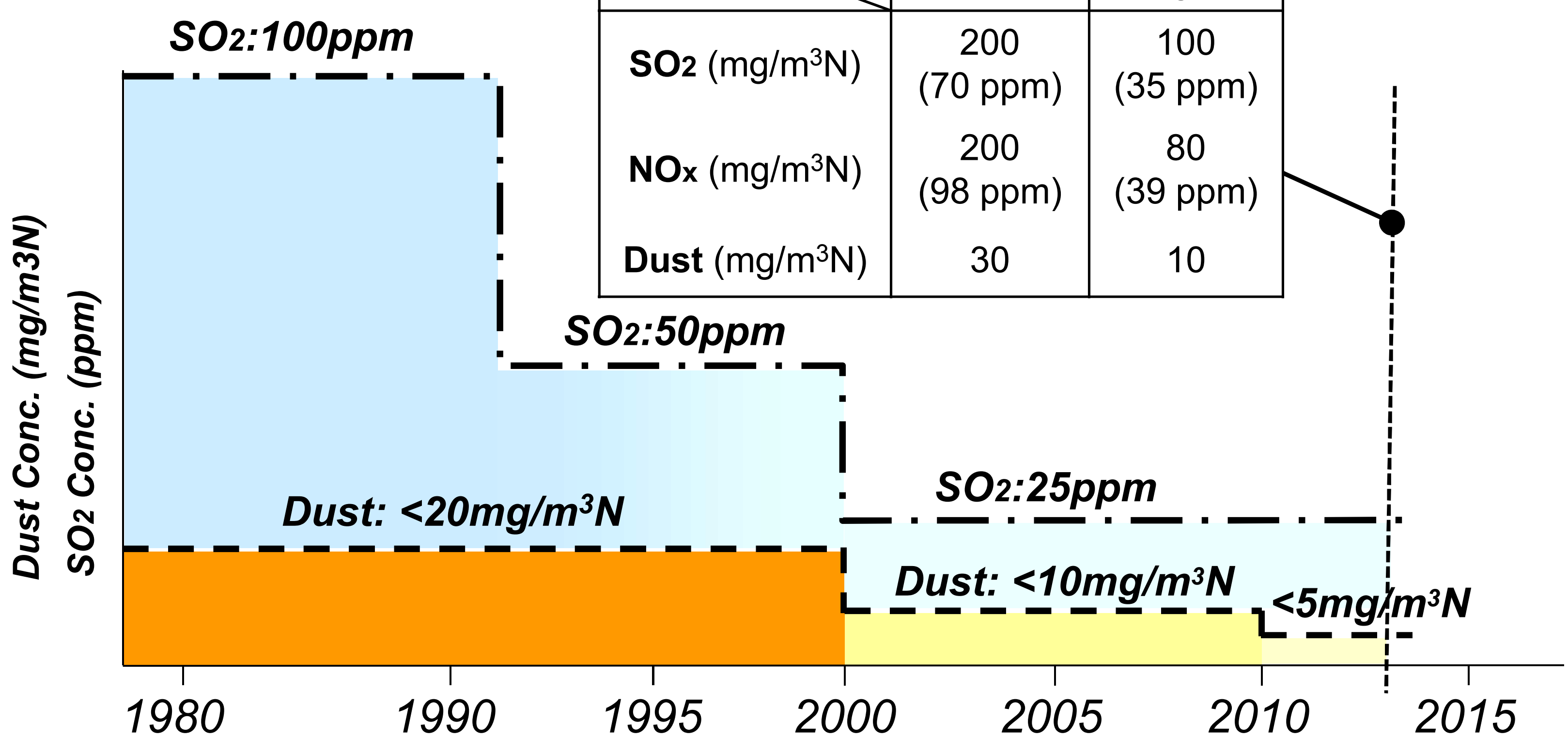

	EU	Germany
SO_2 (mg/m³N)	200 (70 ppm)	100 (35 ppm)
NO_x (mg/m³N)	200 (98 ppm)	80 (39 ppm)
Dust (mg/m³N)	30	10

- ***Severe Standards of SO_2 Conc.*** : ***Improvement of the FGD System***
- ***Severe Standards of Dust Conc.*** : ***Improvement of the Flue Gas System***

→ ***Optimized Combination of the Flue gas System***

1.2 Conventional Flue Gas Treatment System

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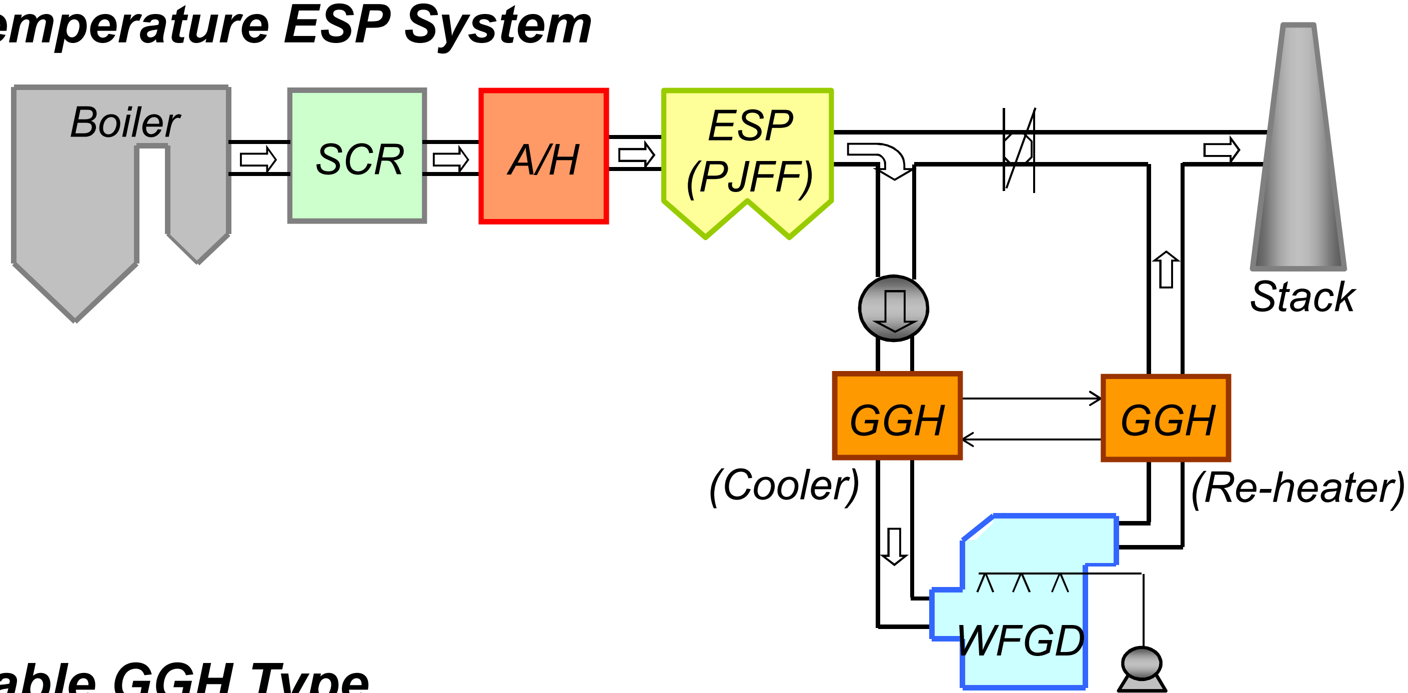
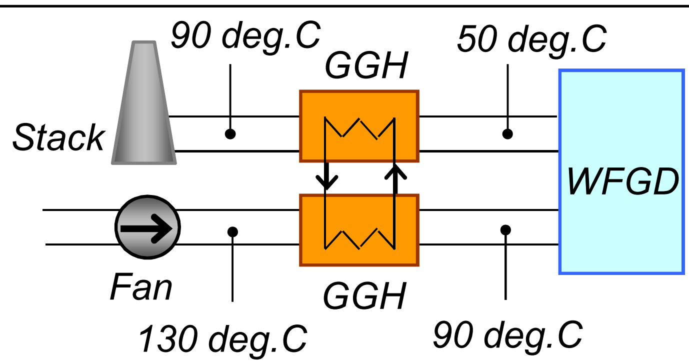
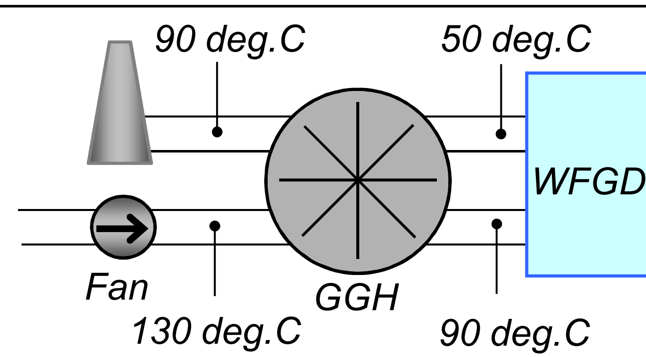
Low Temperature ESP System



Applicable GGH Type

	Non-Leakage Type	Rotary Regenerative Type
GGH		

1.3 Critical Design Factor for GGH Cooler: D/S

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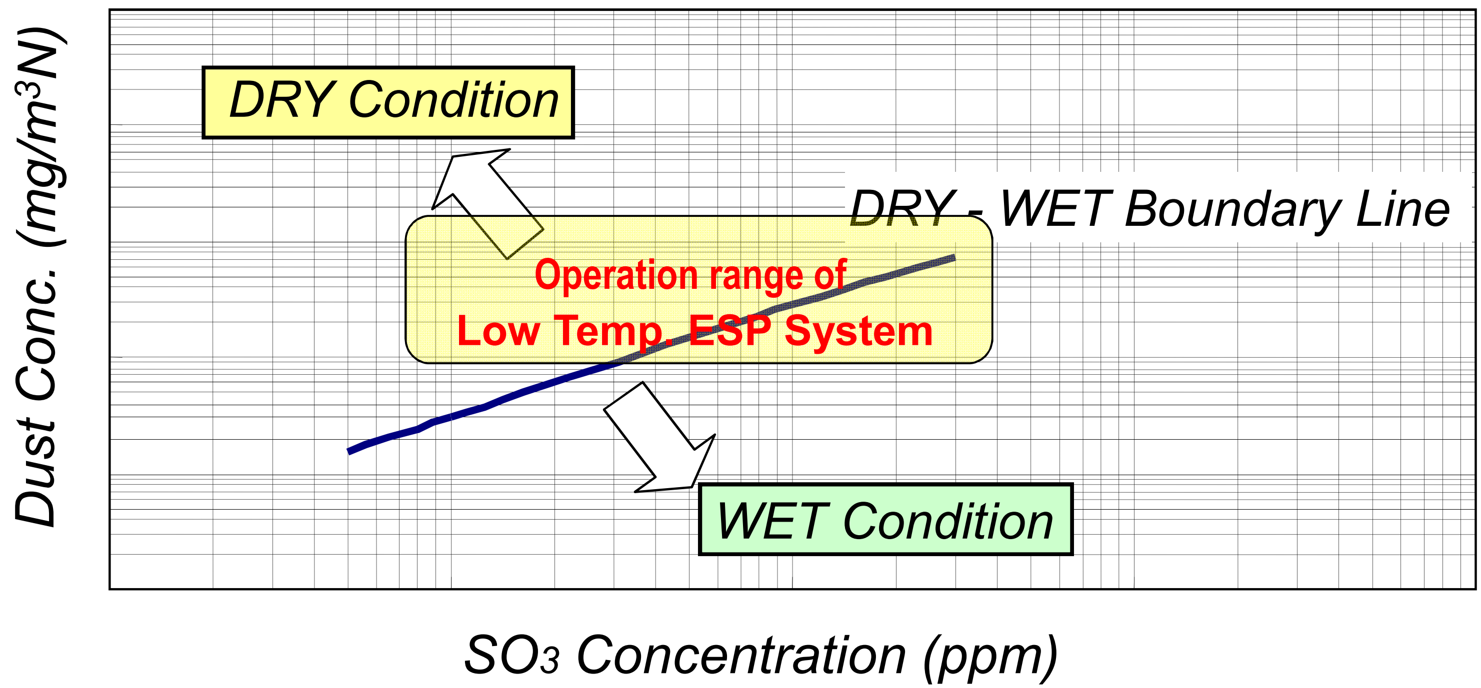

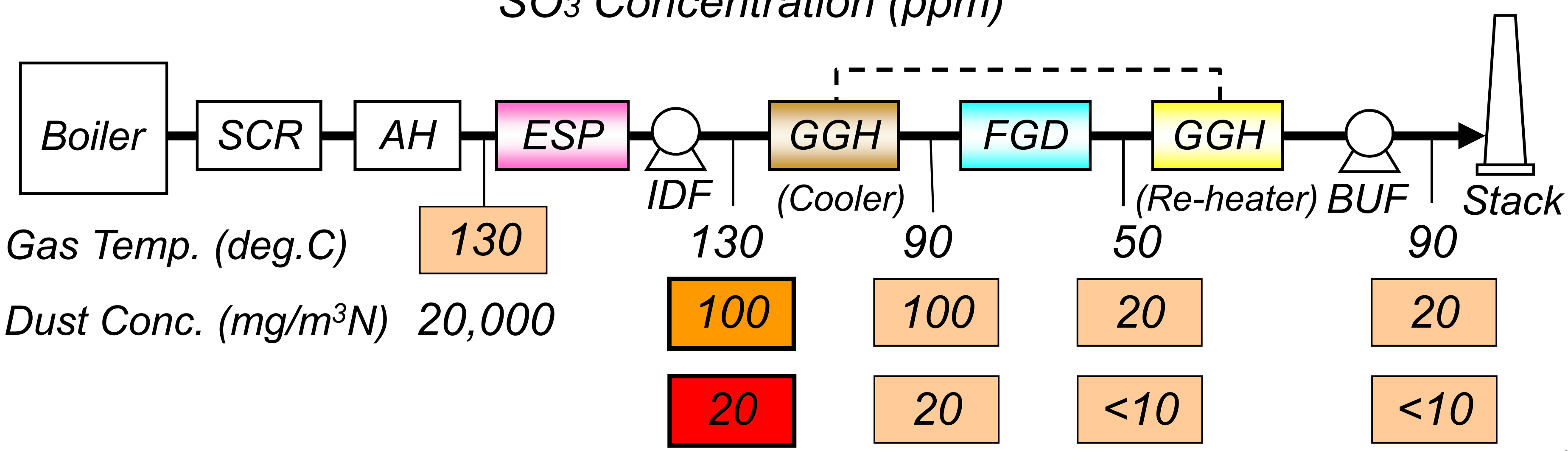

1.4 Trend of GGH Pressure Loss (Conventional)

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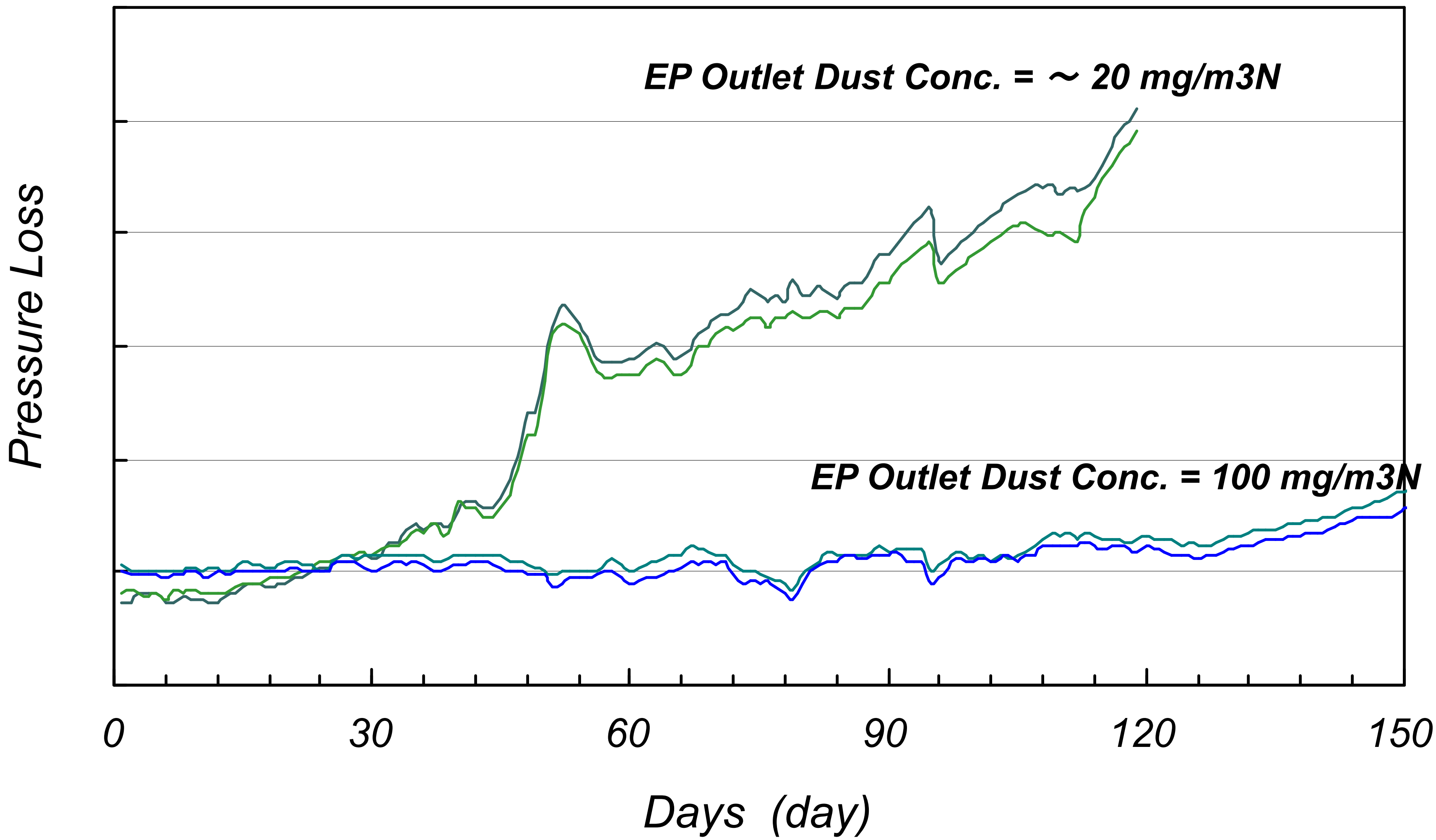
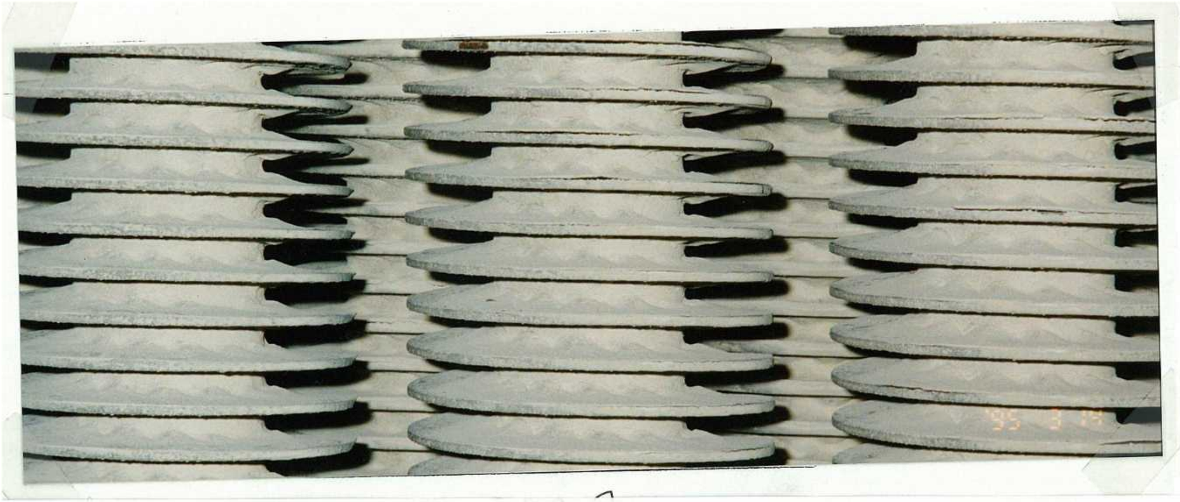
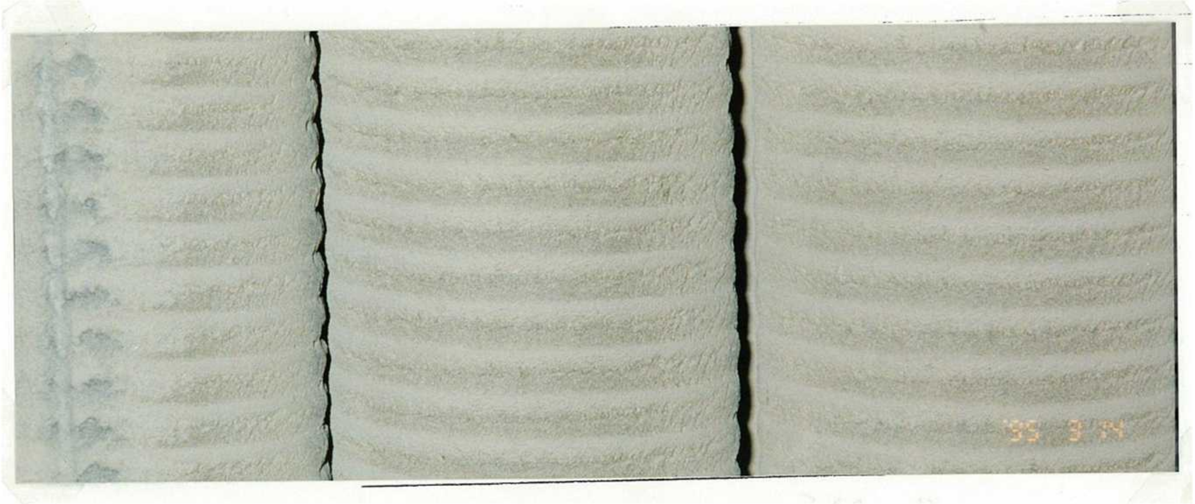


1.5 Heat Recovery Tubes (Low Dust Operation)

Initial



After the operation



1.6 Advanced Flue Gas Treatment System

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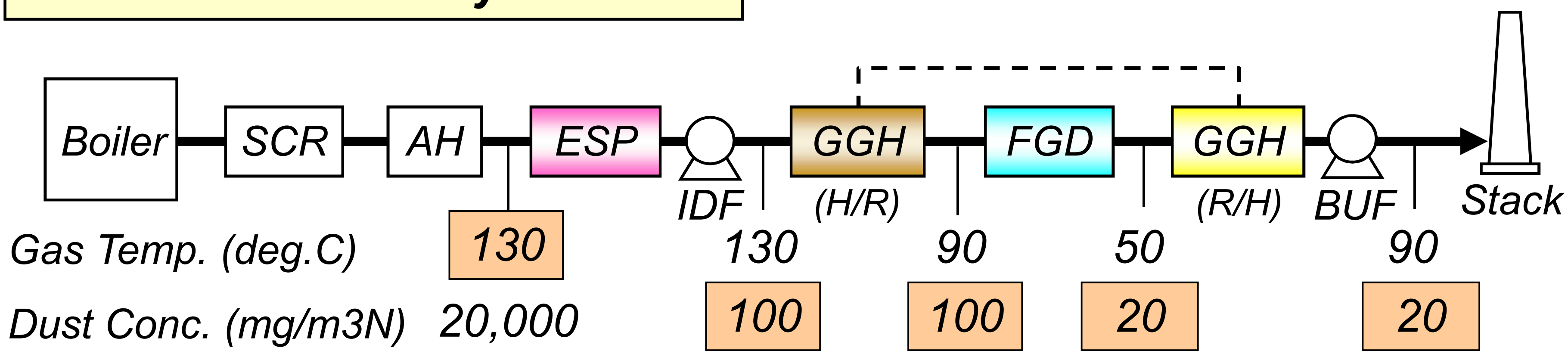
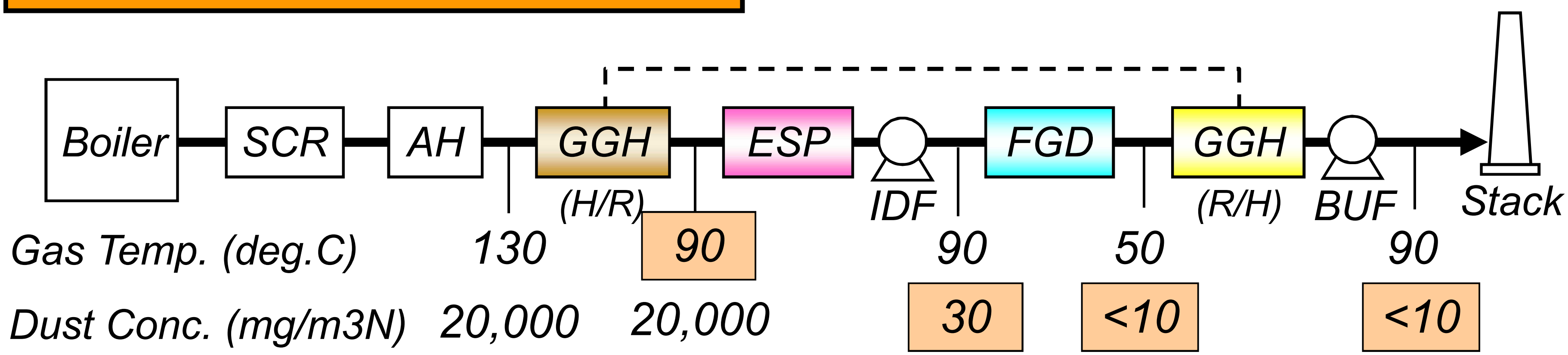
Conventional System



Low-Low Temp. ESP System



1.7 The Features of Low-Low Temp. ESP System

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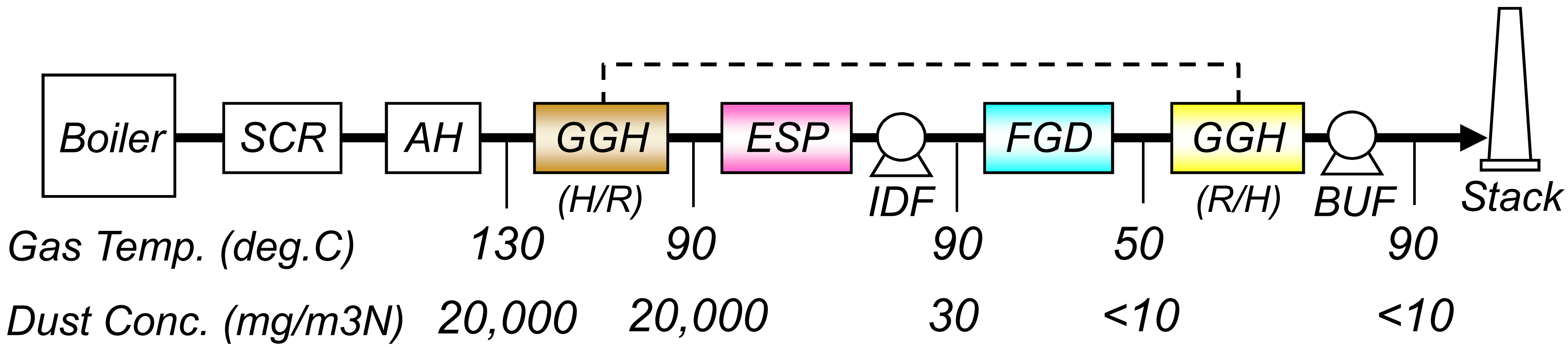

1. *Stable high dust removal performance in ESP (Low gas temperature in ESP)*

2. *No plugging and corrosion by high ash loading andSO_3 condensation in heat recovery (cooler) side of GGH*

3. *Lower fan power consumption (Lower actual gas volume with low temp.)*

1.8 Stable High Dust Removal in DESP

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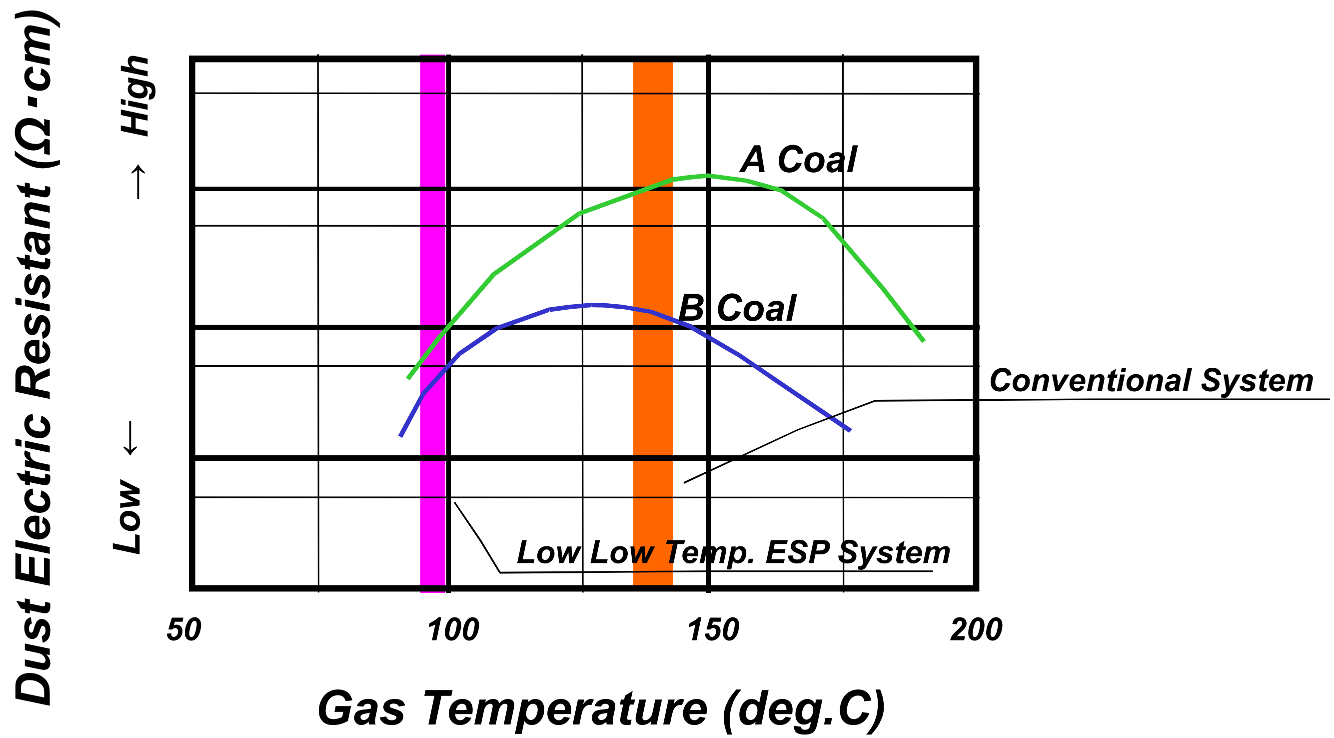
Decrease of ESP Inlet Gas Temp. → *Decrease of Dust Electric Resistant* → *Improve of ESP Performance*



1.9 SO_3 Behavior around GGH (Cooler)

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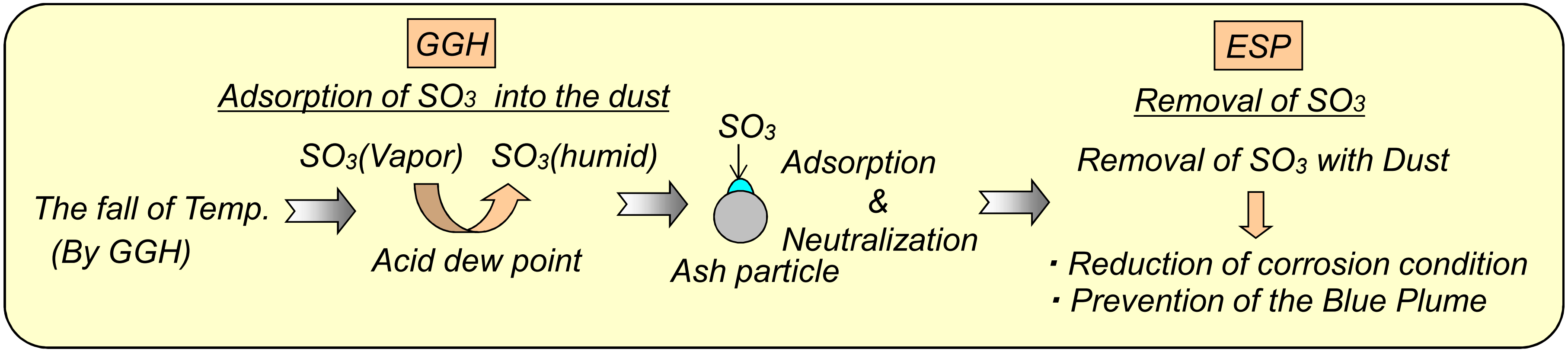
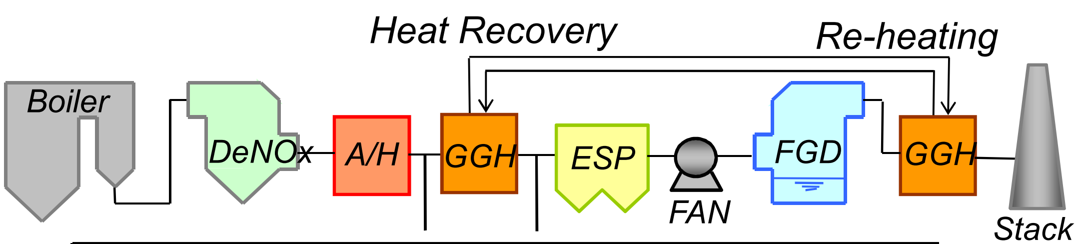
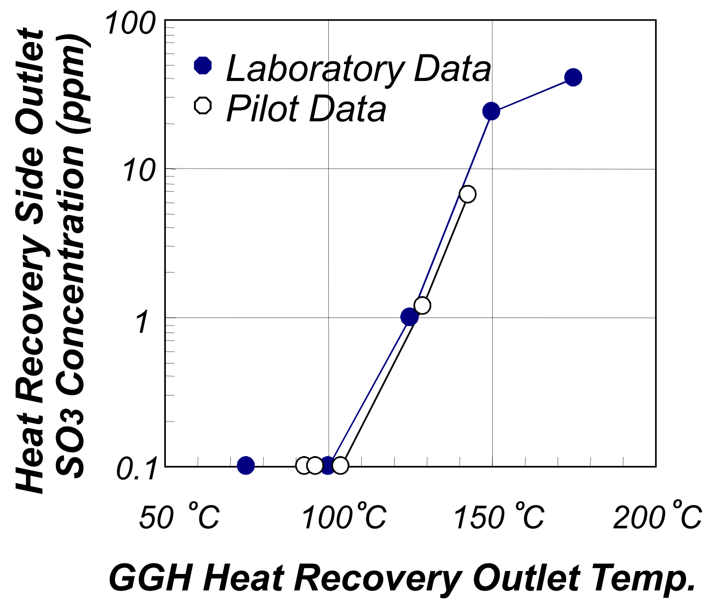
(1) The concept of SO_3 Removal



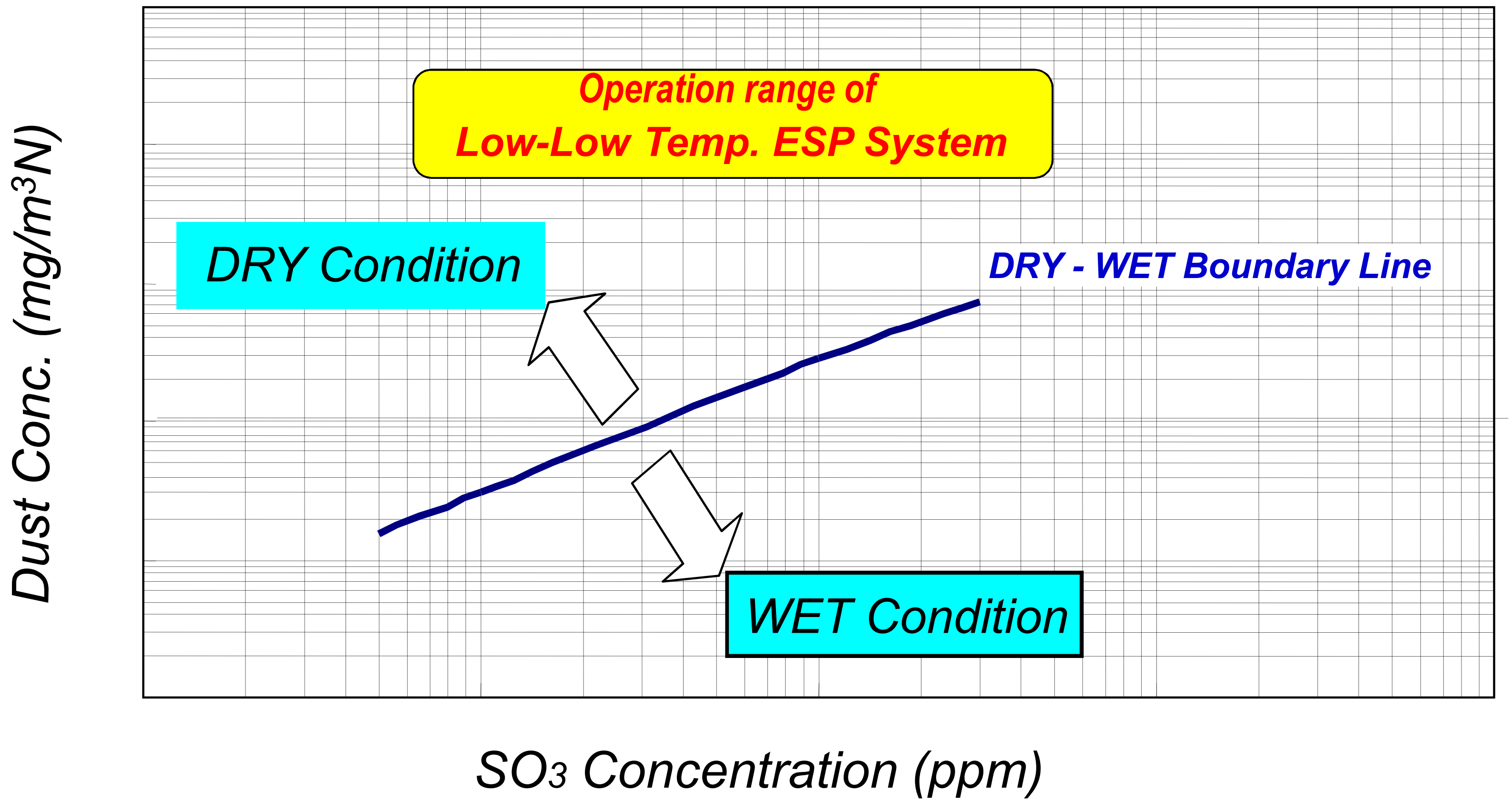
(2) SO_3 measurement data at Pilot Test



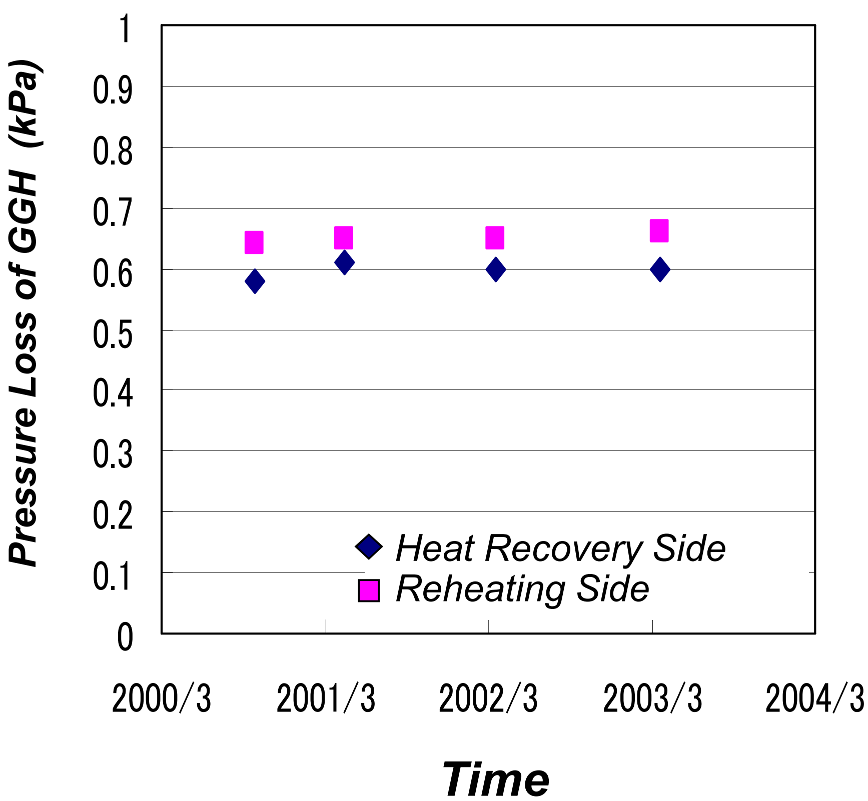
Temp.(℃)	150 - 160	93 - 104	
SO_3 (ppm)	16	< 0.1	Pilot Test
SO_3 (ppm)	50	< 0.1	Laboratory Test



1.10 Dust Rich Circumstances keep Dust Dry



1.11 Reheater Tubes after Operation



After 2 years operations (Cooer Side)

1.12 Supply List of GGH System (1/2)

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No	Customer	Location	Capacity (m^3N/h) (Equiv. MW)	Fuel	Commercial Operation	Remarks
1	Tokyo Electric Power Co., Ltd	Yokosuka #2	925,000 (265)	COM	6-1985	
2	Chugoku Electric Power Co., Ltd	Tamashima #3	1,460,000 (500)	OIL	5-1987	
3	Taiwan Power Co., Ltd	Hsinta #1	1,934,000 (500)	COAL	5-1990	
4	Taiwan Power Co., Ltd	Hsinta #2	1,934,000 (500)	COAL	5-1990	
5	Taiwan Power Co., Ltd	Linkou #1	1,160,430 (300)	COAL	4-1991	
6	Taiwan Power Co., Ltd	Linkou #2	1,160,430 (300)	COAL	4-1991	
7	Soma Joint Thermal Development Co., Ltd	Shinchi #1	3,175,000 (1,000)	COAL	6-1994	
8	Kyushu Sekiyu Co., Ltd	Ohita #1	439,700 (149.4)	R.O.	4-1999	
9	Electric Power Development Co., Ltd	Tachibanawan #2	3,280,000 (1,050)	COAL	12-2000	LLTE

Note: "COM"; Coal Oil Mixture, "R.O.": Residue Oil, "LLTP"; Low-Low Temp. ESP

1.13 Supply List of GGH System (2/2)

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No	Customer	Location	Capacity (m^3N/h) (Equiv. MW)	Fuel	Commercial Operation	Remarks
10	Chubu Electric Power Co., Ltd	Hekinan #4	2,916,000 (1,000)	COAL	11-2001	LLTE
11	Chugoku Electric Power Co., Ltd	Tamashima #2	1,000,000 (350)	OIL	7-2001	
12	Chubu Electric Power Co., Ltd	Hekinan #5	2,916,000 (1,000)	COAL	11-2002	LLTE
13	Idemitsu Sekiyu Co., Ltd	Aichi #3	782,400 (252)	OIL	4-2004	
14	Kansai Electric Power Co., Ltd	Maizuru #1	2,620,000 (900)	COAL	8-2004	LLTE
15	Korea South-East Power Co., Ltd	Yonghung #3	2,474,820 (870)	COAL	6-2008	LLTE
16	Korea South-East Power Co., Ltd	Yonghung #4	2,474,820 (870)	COAL	3-2009	LLTE
17	Kansai Electric Power Co., Ltd	Maizuru #2	2,465,000 (900)	COAL	8-2010	LLTE
18	Tokyo Electric Power Co., Ltd	Hitachinaka #2	3,400,000 (1,000)	COAL	12-2013 (Scheduled)	LLTE

Note: "COM"; Coal Oil Mixture, "R.O.": Residue Oil, "LLTP"; Low-Low Temp. ESP

1.14 Case Example - 1

ELECTRIC POWER DEVELOPMENT CO., / TACHIBANAWAN P.S. / NO. 2

Low-Low Temperature ESP Flue Gas Treatment System

MAJOR SPECIFCATION

Boiler Fuel:	*Coal*
FGD Process:	*Wet Limestone-gypsum*
Gas Flow Rate:	*3,130,400 m^3 N/h*
	(Eq. : 1,050 MW)
Inlet SO_2 Conc.:	*860 ppm*
Flue Gas System	*Low-Low Temp. ESP*
Gas Reheating:	*Non-leak Type GGH*
Dust Emission	*< 10 mg/m3N*
Operation	*December, 2000*

1.15 Pilot Test Plant (1.5MWth) in BHK/Akitsu

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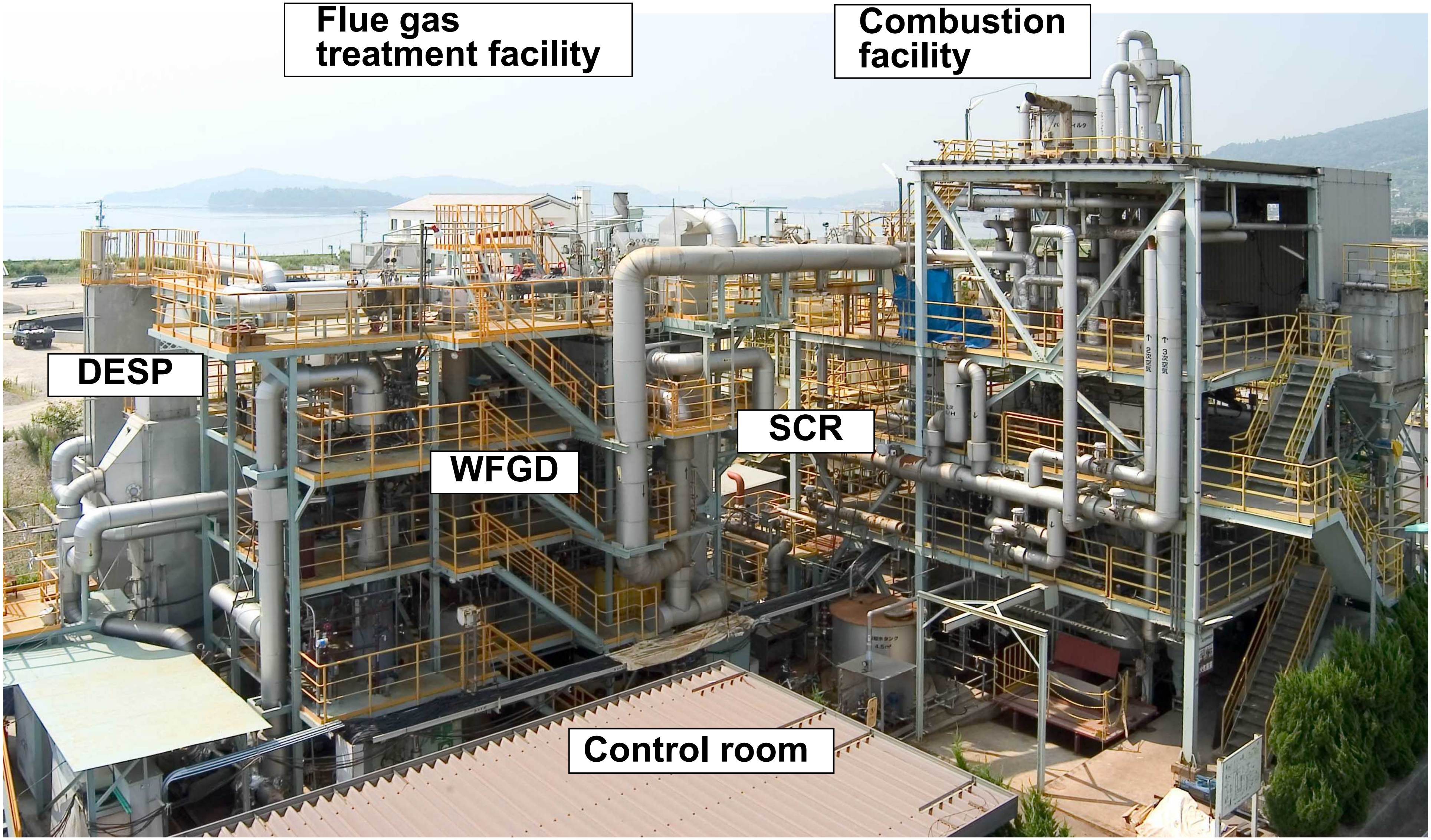
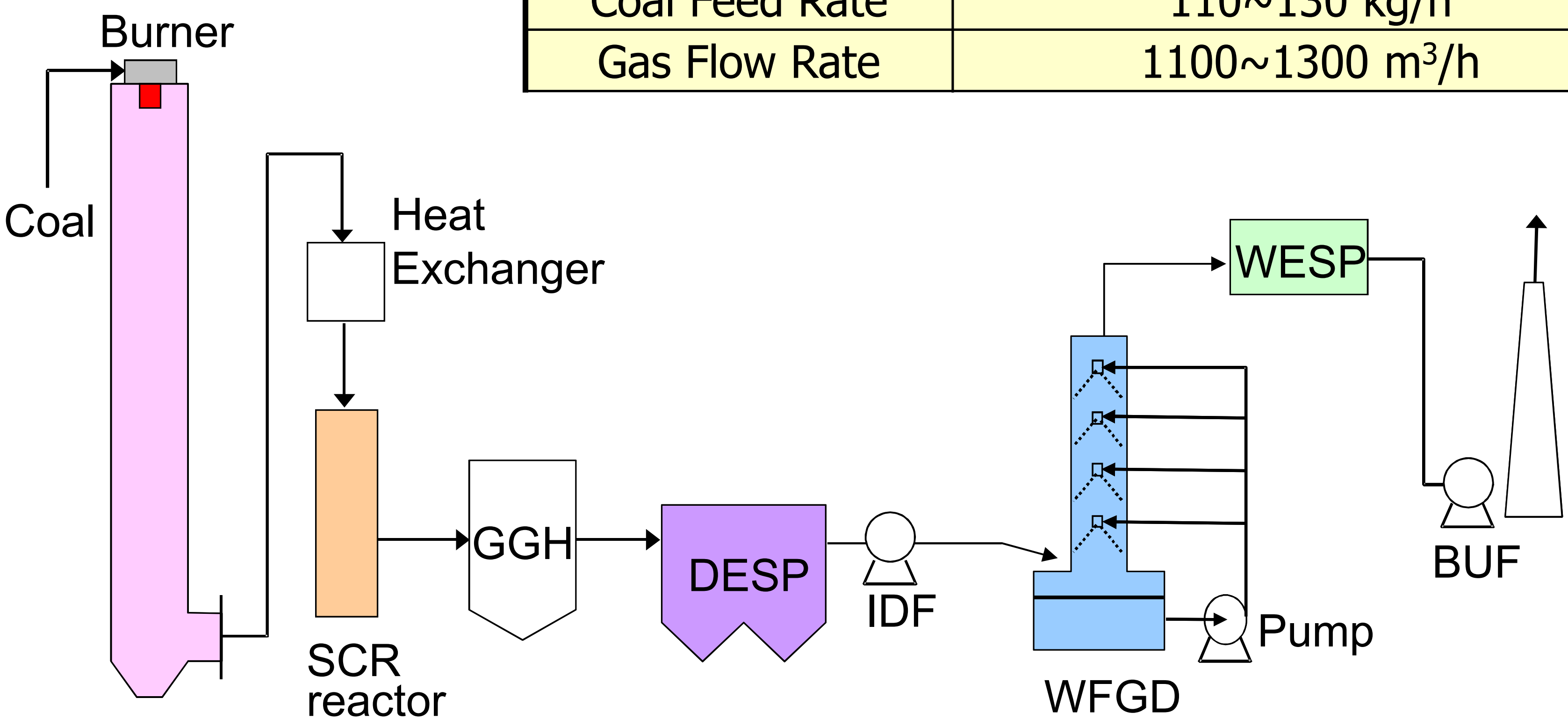


1.16 Schematic Diagram of the Pilot Test Plant

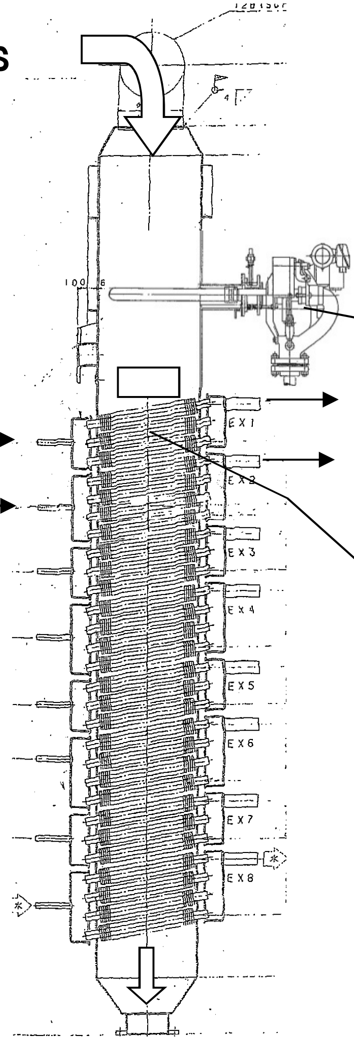
Item	Condition
Coal Feed Rate	110~130 kg/h
Gas Flow Rate	1100~1300 m^3/h



SCR : Selective Catalytic Reduction
GGH : Gas-Gas Heat exchanger
DESP : Dry Electrostatic Precipitator
WFGD : Wet Flue Gas Desulfurization
WESP : Wet Electrostatic Precipitator

Exhaust Gas

Cooling medium



a Structure of Gas-Gas Heater

Nozzle

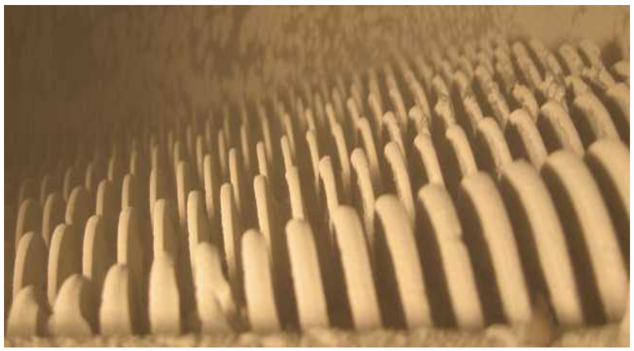
Seal Air

Compressor Air

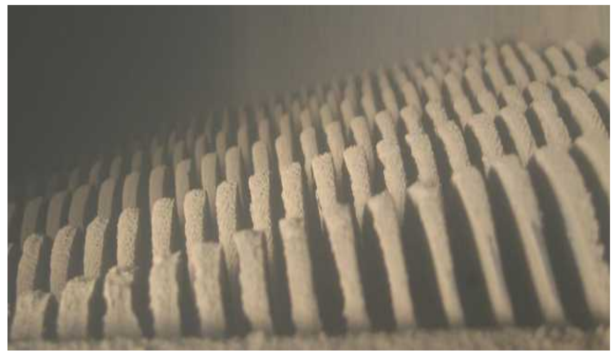
b Soot Blower

c Finned tube

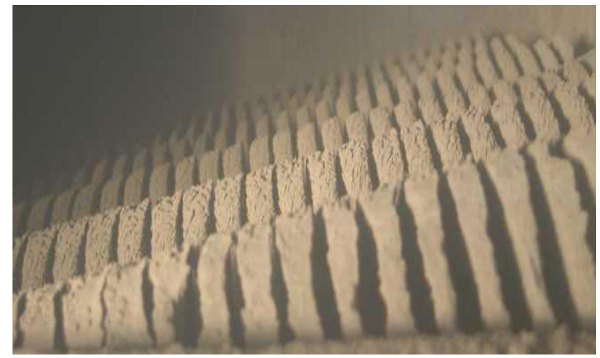
1.18 Condition of Finned tube



a SO_3=43mg/Nm^3 (12ppm)



b SO_3= 143mg/Nm^3 (40ppm)



c SO_3= 321mg/Nm^3 (90ppm)

- The amount of ash accumulated on the tubes increased with increasing SO_3 concentration in the flue gas.

1.19 Effect of Soot Blower

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(movie file)

(movie file)

SO_3=143mg/m3N
(40ppm)
Gas Temp.=130 degC

SO_3=286mg/m3N
(80ppm)
Gas Temp.=130 degC

2. Mercury Removal Using Special SCR Catalyst (TRAC®)

2.1 Process of Mercury Removal

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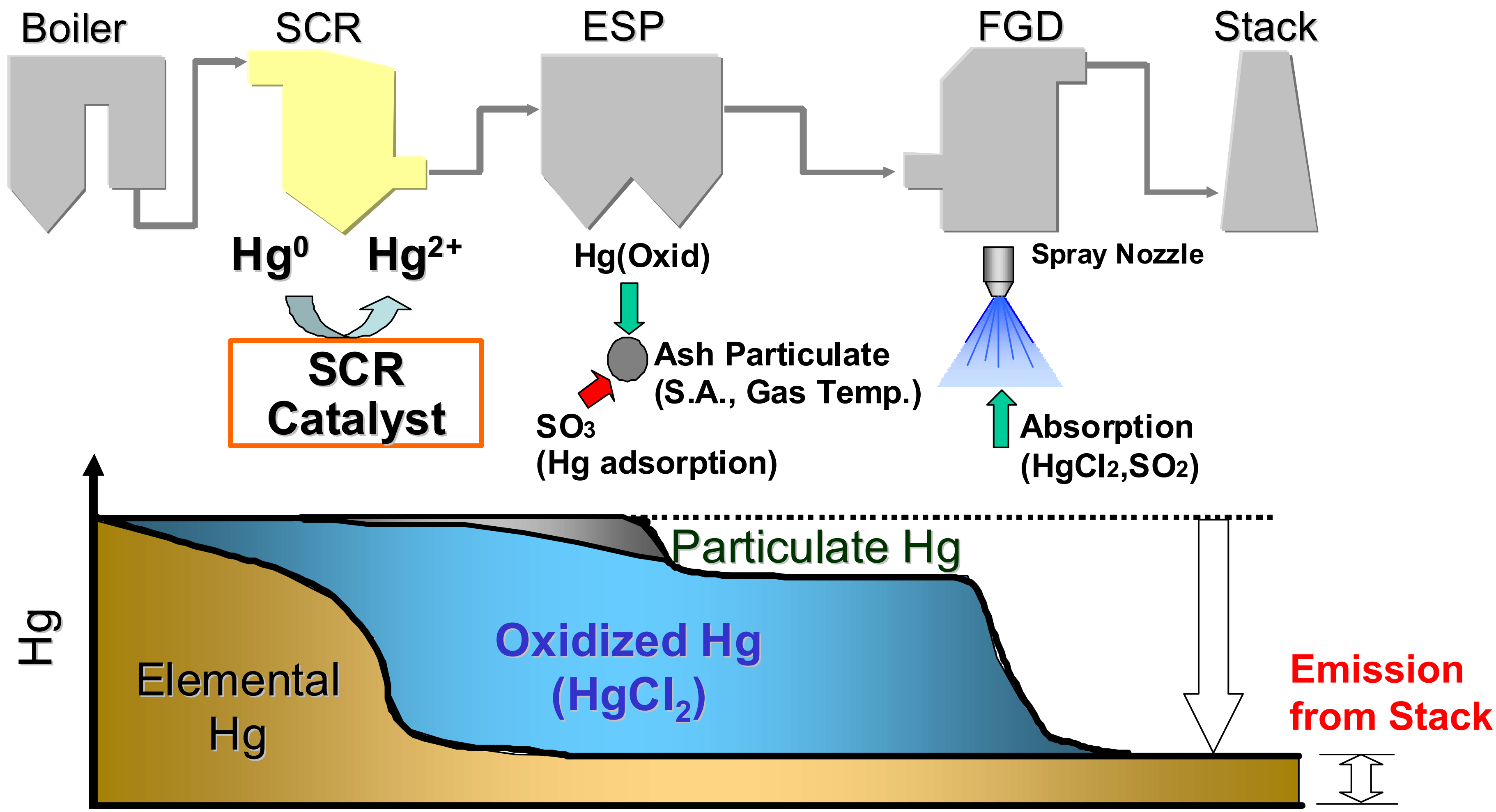

SCR catalyst is a key component for mercury removal

2.2 Mercury Removal Key Technology

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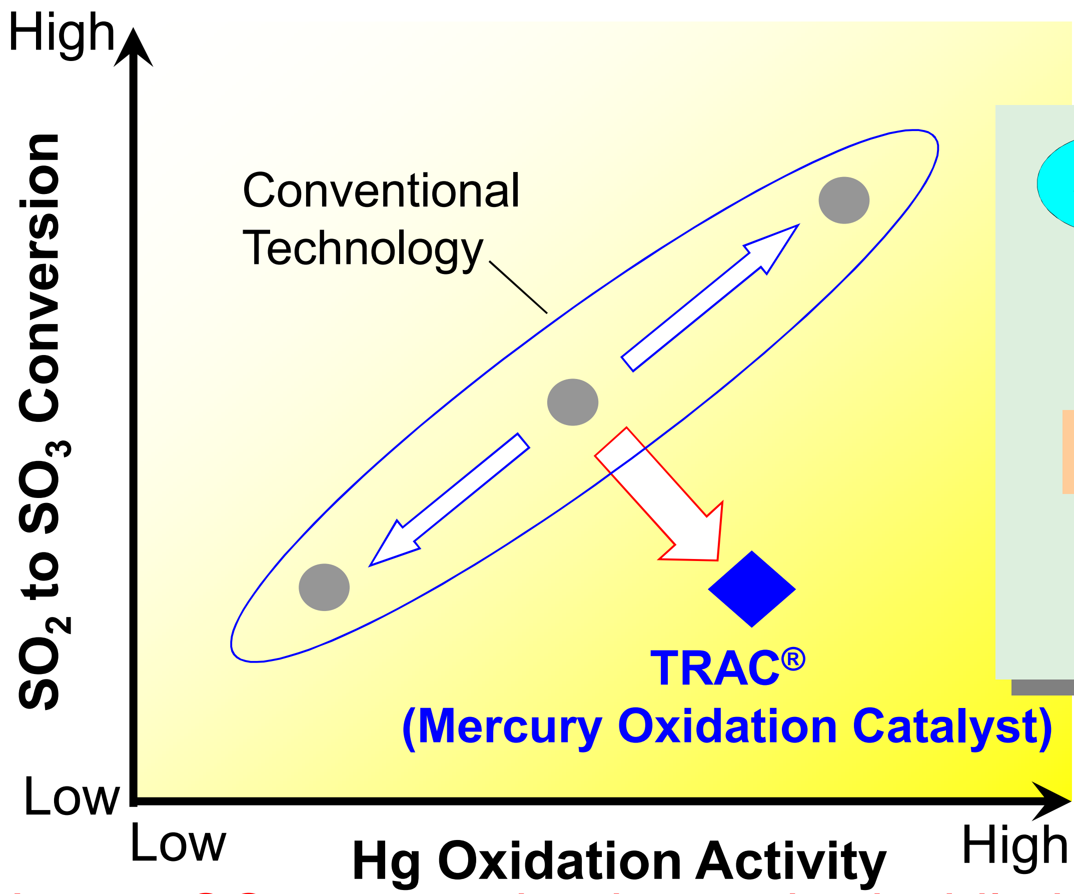
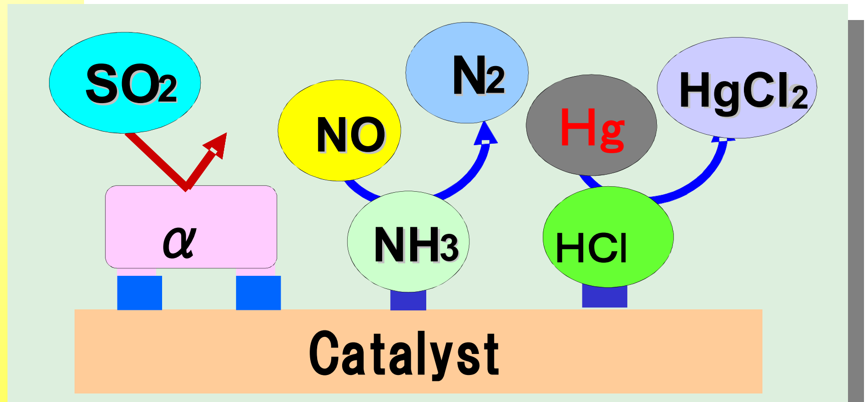
Technology	Key Item	Advantage	Disadvantage/Challenge
Adsorption	**Activated Carbon Injection (ACI)**	- Commercialized - w/o SCR - High Hg removal	***- High Operating Cost*** ***- Difficulty of ash disposal*** - Addition of ACI facility - Difficulty of Operation and Maintenance - SO_3 impact on Hg removal efficiency
Oxidation	**Halogen Injection**	- Commercialized - Simple system - High Hg removal - Relatively low cost	- Balance of plant impacts - Ineffective on bituminous coal
	SCR Catalyst	***-Commercialized*** ***- Low operating cost*** ***- No additional facility*** ***- Easy to replace*** ***- High operation reliability***	-Correspondence with Customer's needs





$$SO_2 + 1/2O_2 \rightarrow SO_3$$
$$Hg + 2HCl + 1/2O_2 \rightarrow HgCl_2 + H_2O$$

Lower SO_2 conversion is required while keeping higher Hg oxidation.

TRAC® = Triple Action Catalyst

2.4 Key Parameters for Mercury Oxidation

Hg Oxidation Rate

- ***NH_3/NOx ratio***
- ***Temperature***
- ***Halogen concentration (HCl, HBr etc.)***
- ***Catalyst Deterioration***
- ***Area velocity (volume)***
- ***SO_2, SO_3 concentration***
- ***O_2 concentration***
- ***H_2O concentration***
- ***Hg^0 / Hg^{2+} ratio***

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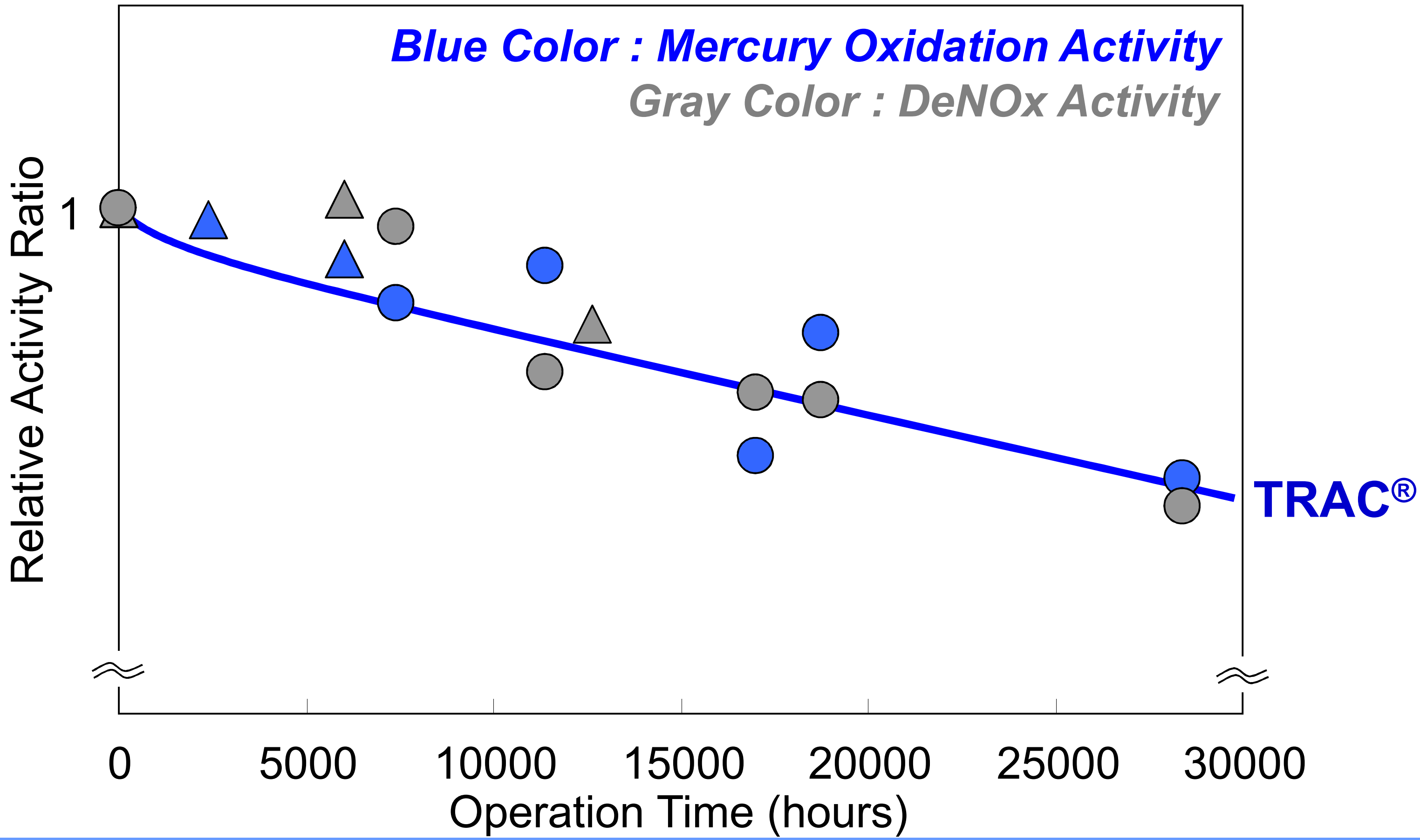
Deterioration rate



Hg Oxidation and DeNOx activity deterioration rates of TRAC® trace the same curve with excellent Durability

2.6 Full-Scale Results for PRB Unit (1/2)

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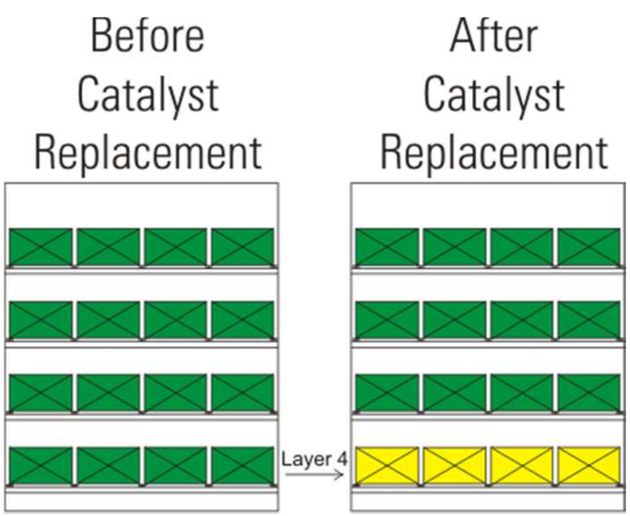
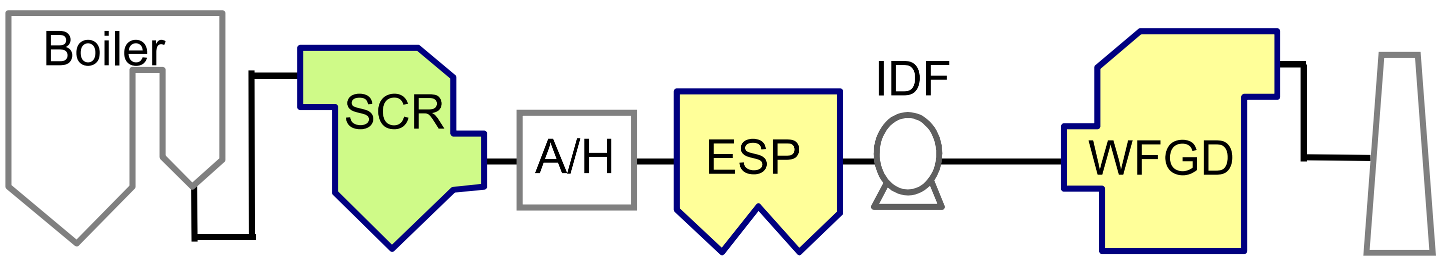
- Plant Capacity: 720 MW
- PRB Coal
- TRAC® Supplied in spring 2011



Hg Removal: **30%** → **60%**

Flue Gas Condition

Stack Gas Flow Rate	3,397,200 m^3N/hr
Temperature	382 ℃
NOx	130-230 ppm
SO_2	125-325 ppm
HCl	**Approx. 3 ppm**
NOx Removal	90 %
Slip NH_3	<2 ppm



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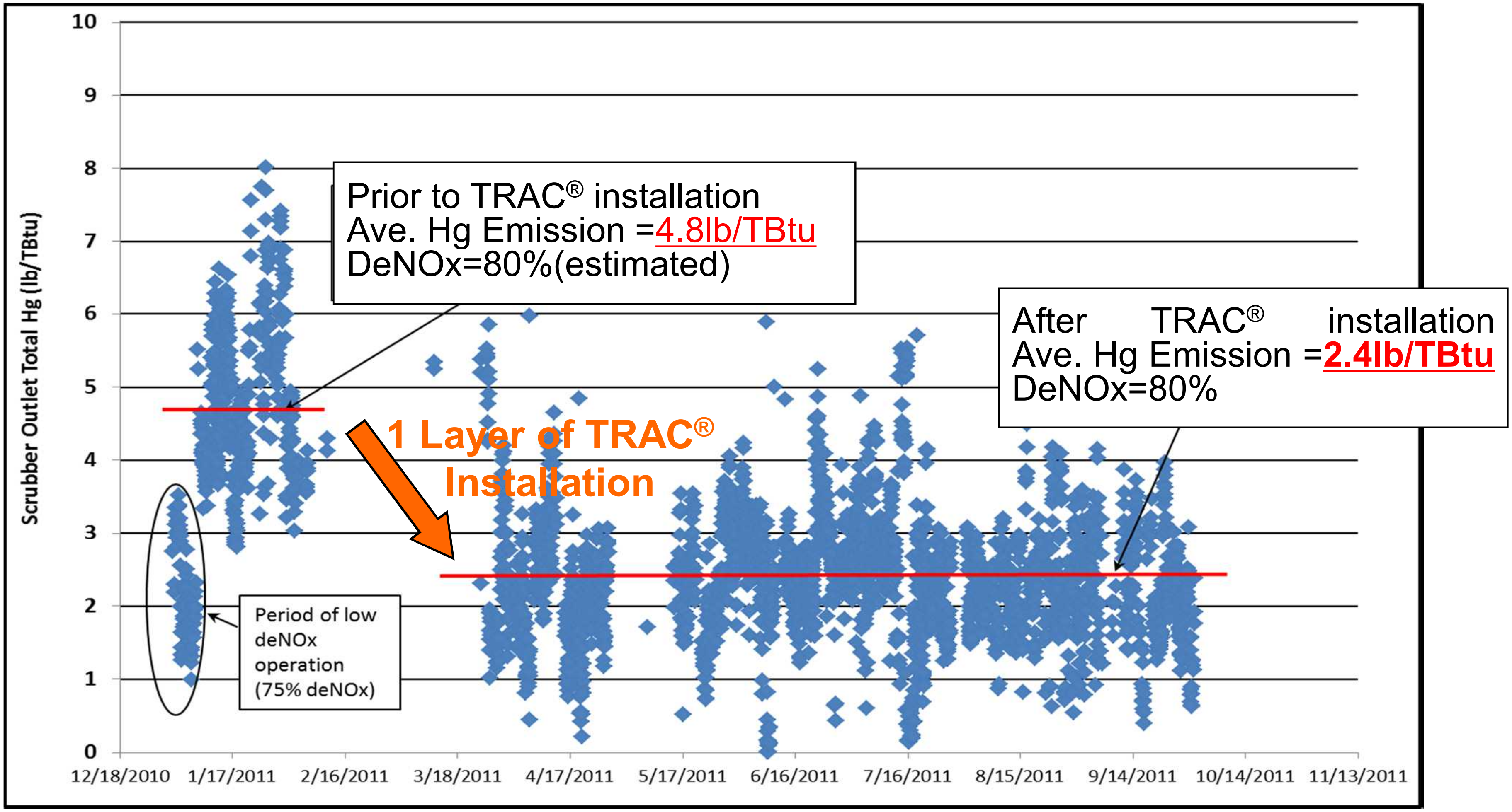
Hg-CEM (Continuous Emission Monitor) at the Stack



2.8 Full Scale Results for Bituminous Units (1/3)

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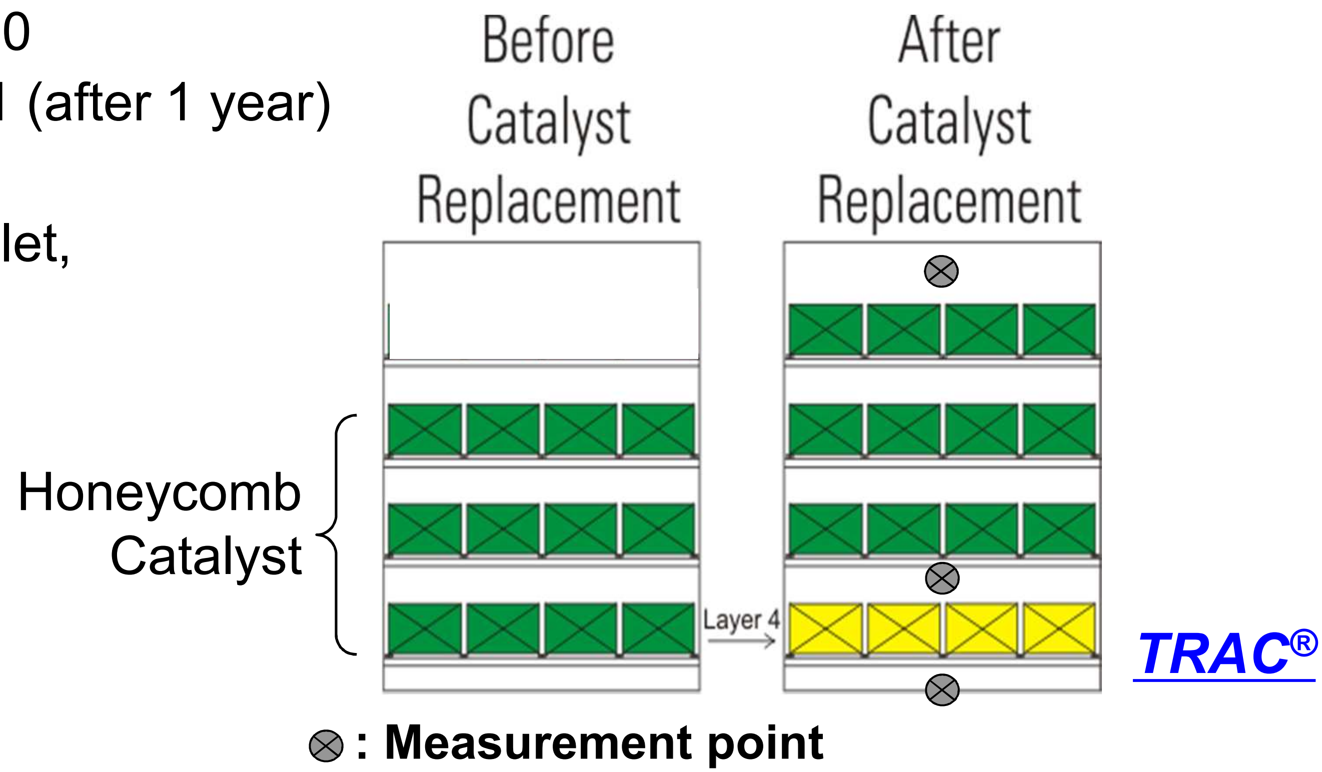
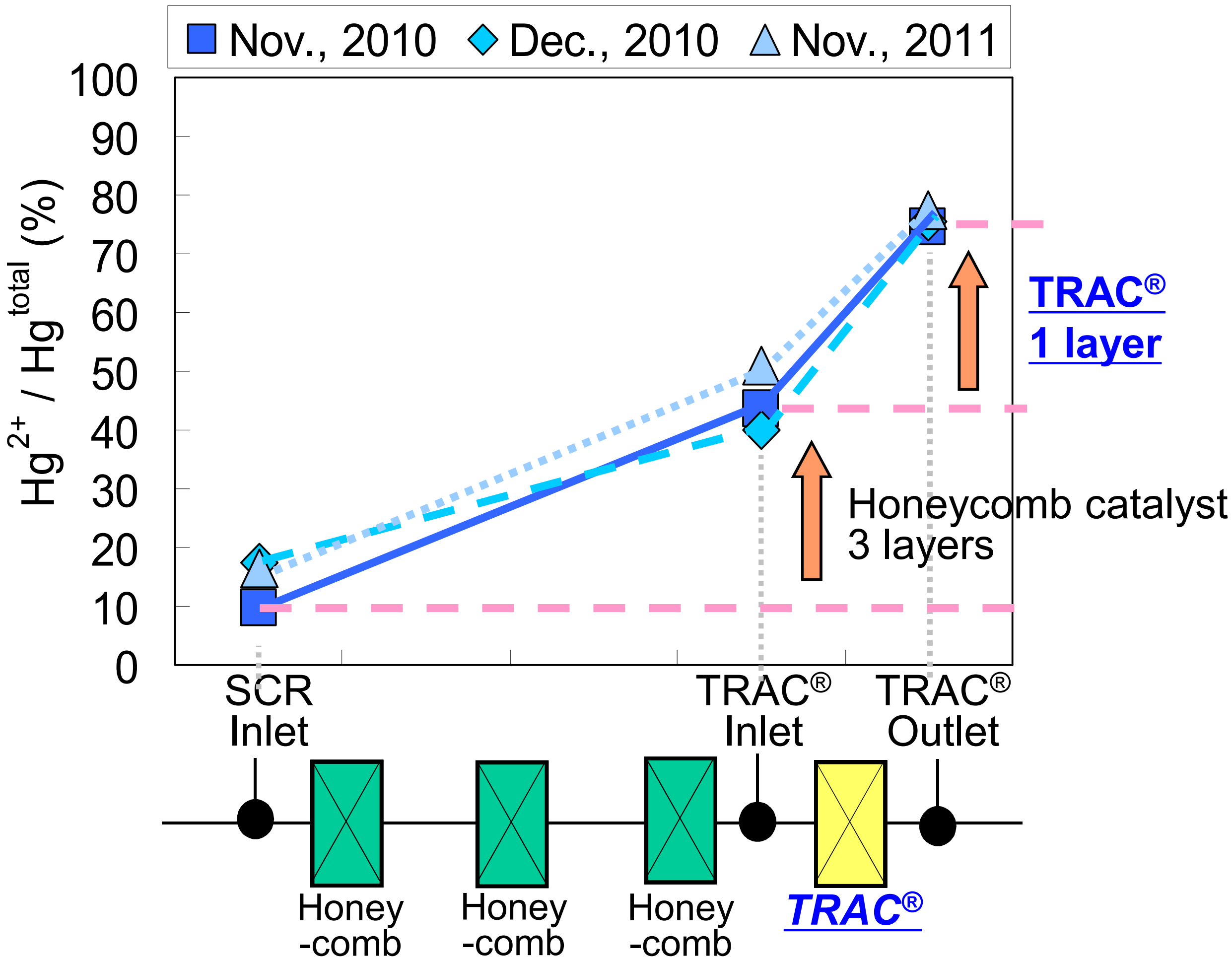
- Bituminous fired Plant (550 MW)
- Bituminous Coal
- TRAC® Supplied in spring 2010
- Measurement Date :
  1st Run – Nov., 2010
  2nd Run – Dec., 2010
  3rd Run – Nov., 2011 (after 1 year)
- Measurement point :
  SCR Inlet, TRAC® Inlet,
  TRAC® Outlet

Flue Gas Condition

Temperature	725 F
Hg in coal	0.043 – 0.073 ppm
Cl in coal	43 – 120 ppm

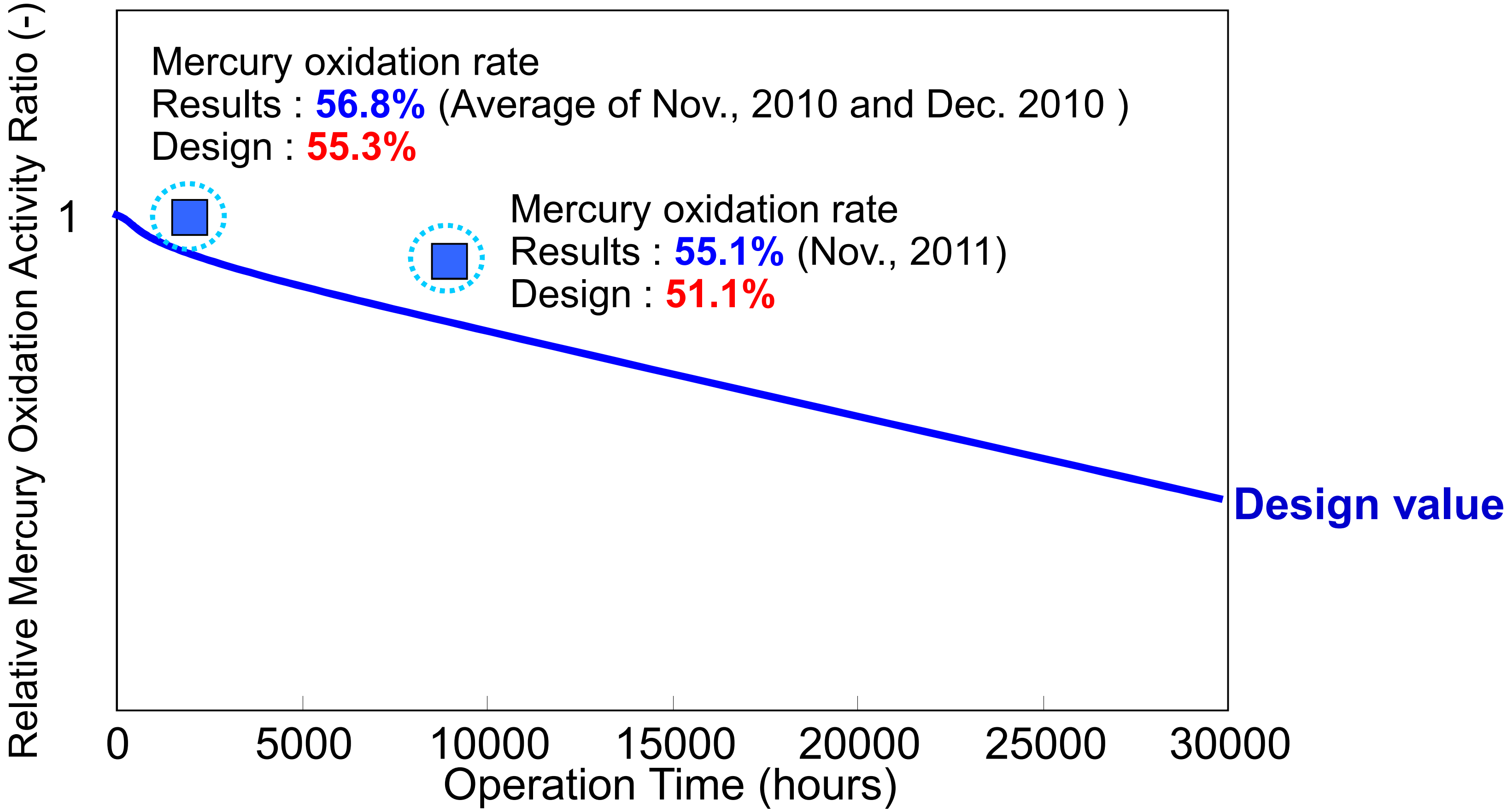


2.9 Full Scale Results for Bituminous Units (2/3)



80 % of Hg oxidation was achieved by adding 1 layer of TRAC® from 40% by 3 layers Honeycomb

2.10 Full Scale Results for Bituminous Units (3/3)



Hg oxidation activity is still high at one year operation.

2.11 TRAC® Record

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No.	Owner	Load (MW)	Coal	Supply	Country
1	A	640	PRB	2008	US
2	B	550	Bituminous	2010	EU
3	SC	735	PRB	2011	US
4	SC	735	PRB	2011	US
5	SC	773	Bituminous	2011	US
6	AEP	1,300	Bituminous	2011	US
7	SC	950	Bituminous	2011	US
8	AEP	600	Bituminous	2012	US
9	C	800	Bituminous	2012	EU
10	SC	537	Bituminous	2012	US
11	SC	910	Bituminous	2012	US
12	SC	950	Bituminous	2012	US
13	D	511	Bituminous	2013	US
14	E (Full Layers)	418	PRB	2013	US

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