BABCOCK BORSIG POWER

Radiant Superheater Surface Addition

for
Intermountain Power
Unit 1
BBP 100210

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Agenda for Boiler Modeling Discussion

1. **Review Baseline Testing**
   - Test conditions
   - Data analysis
   - Test results
2. **Review Math Model Development**
   - Geometry
   - Effectiveness Factors
   - Math Model Results
3. **Predicted Performance**
   - Surface modification
   - FEGT & Q/A Effects
   - Predicted Performance
     - 900 MW, 950 MW
4. **Pressure Drop**
5. **Metals**
6. **Target Performance**
7. **Questions**
8. **Post Modification Testing**

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Baseline Testing September 25-26, 2002

Objectives

Test at 900 MW and a lower load

Collect required data to set up computer heat transfer mathematical models

- Intermediate steam and water temperatures
- Local O2 and gas temperatures at backpass and AH inlets/outlets
- Backpass gas split determination
- Spray takeoffs
- Turbine heat balance data sheets/feedwater heater data
- Heating surface information

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Baseline Testing September 25-26, 2002

Results

Conducted 3 Tests at 900 MW

- Unable to run at lower load
- Unable to get local data

End Result - Obtained the majority of the required data to needed to set up math models.

Subsequent to testing:

- Obtained a set of data for boiler operation at 950 MW
- Received the remaining heating surface information

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Test Data Summary

	Units	Test 1	Test 2	Test 3	Test 4
MW	MW	900	900	900	950
Fuel	lbm/hr	Coal	Coal	Coal	Coal
Excess Air	%	13.86	13 31	12 05	14.86
Feedwater flow	lbm/hr	6,214,290	6,263,947	6,186,240	6,723,341
Main steam flow	lbm/hr	6,285,545	6,310,995	6,237,785	6,743,404
Reheat steam flow	lbm/hr	5,146,618	5,166,006	5,110,235	5,494,398
Superheater spray flow 1st stage	lbm/hr	12,606	12,507	12,449	3,080
Superheater spray flow 2nd stage	lbm/hr	58,649	34,541	39,096	16,893
Reheat spray flow	lbm/hr	0	0	0	0
Flue gas flow split	%SH/RH	73.1/26.9	69/31	72 5/27 5	71/29
Total flue gas flow	lbm/hr	7,461,548	7,425,841	7,314,629	7,652,368
Total fuel flow	lbm/hr	633,153	632,949	629,932	672,346
Superheat spray temp	°F	345	345	345	349
Avg. Econ water inlet temp	°F	544	544	544	549
Avg. Econ water outlet temp.	°F	576	576	576	581
PSH before spray temp	°F	723	719	723	722
PSH after spray temp	°F	721	717	721	721
SSH before spray temp	°F	789	782	787	782
SSH after spray temp	°F	779	776	778	779
SSH inlet bank outlet temp	°F	922	922	921	902
Main SH outlet temp	°F	1005	1005	1005	999
Reheat inlet temp	°F	633	633	633	630
Reheat outlet temp	°F	1003	996	1009	1004

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Test Data Summary (cont.)

	Units	Test 1	Test 2	Test 3	Test 4
MW	MW	900	900	900	950
Fuel	lbm/hr	Coal	Coal	Coal	Coal
Excess Air	%	13 86	13 31	12.05	14.86
Economizer inlet pressure	psia	2626	2628	2623	2760
Drum pressure	psia	2544	2546	2542	2669
Superheater outlet pressure	psia	2263	2263	2264	2360
Reheat inlet pressure	psia	574	574	574	606
Reheat outlet pressure	psia	540	541	539	571
FEGT — Furnace Exit Gas Temp	°F	2217	2212	2250	2247
Economizer exit gas temp , avg.	°F	742	739	753	749
Airheater outlet gas temp., uncorr	°F	332	330	329	319
Airheater inlet air temp	°F	102	101	94	99
Airheater outlet air temp	°F	621	619	629	622
Furnace EPRS Heat release	Btu/hr-ft²	96,121	96,008	95,626	101,889
Radiant SH Q/A	Btu/hr-ft²	23,200	23,150	22,400	24,840

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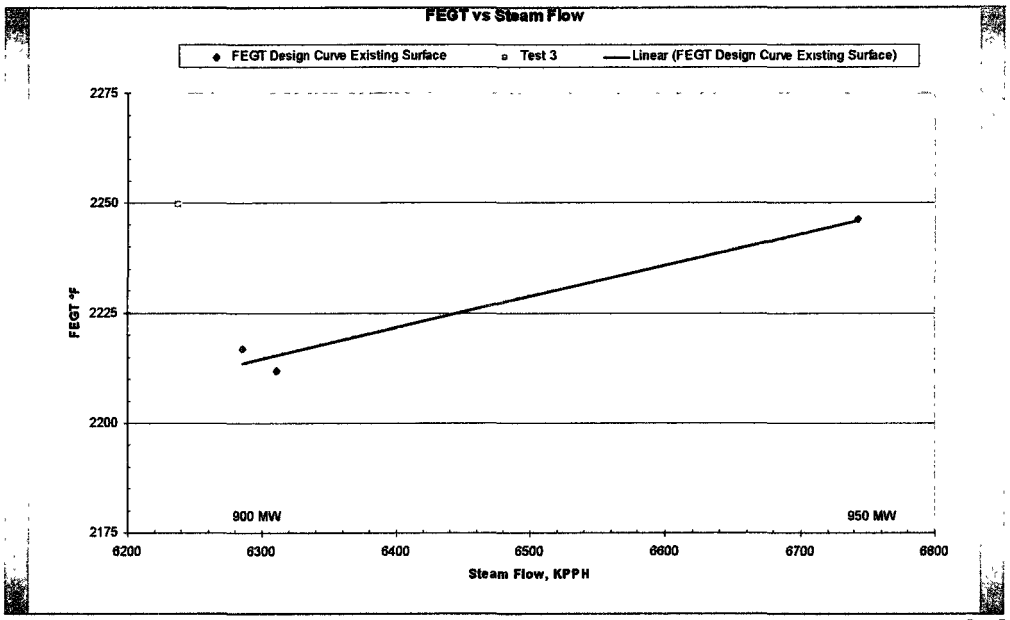

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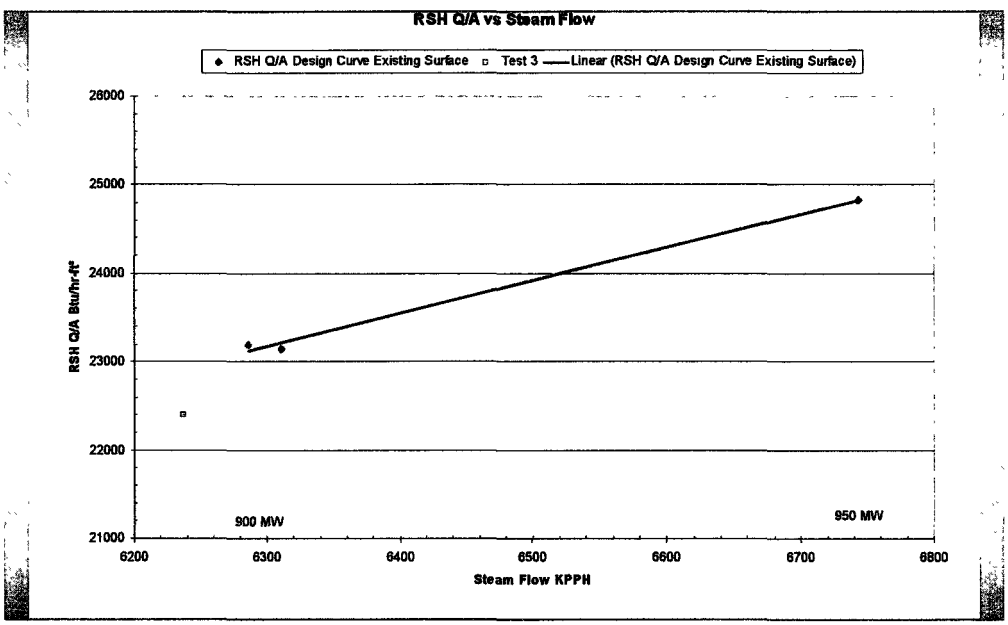


COMPUTER MODELING

Mathematical Representation of a Process

Heat transfer Boiler circulation Boiler tube metals
Fluid flow Combustion process

Two Main Types of Models:

1. Theoretical Model
   - → Based on a Text Book Analysis
2. Calibrated Model
   - → Based on Calibration to Actual Data

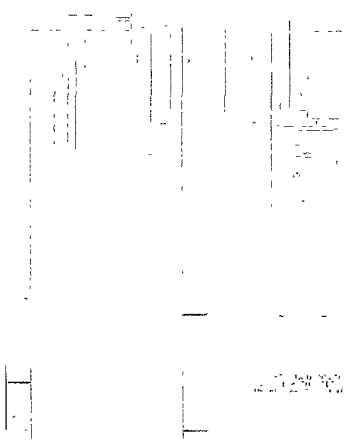
Uses:

- → Predicate Performance at New Physical Operating Conditions
- → "What-If" Analysis
- → Sensitivity Analysis, "Bound the Solution"
- → Evaluate the Complete System "Big Picture"

Input Requirements

- → Detail Physical Arrangement
- → Design Operating Condition
- → Actual Data, if available, for Calibration

Boiler Heating Surface Sketch



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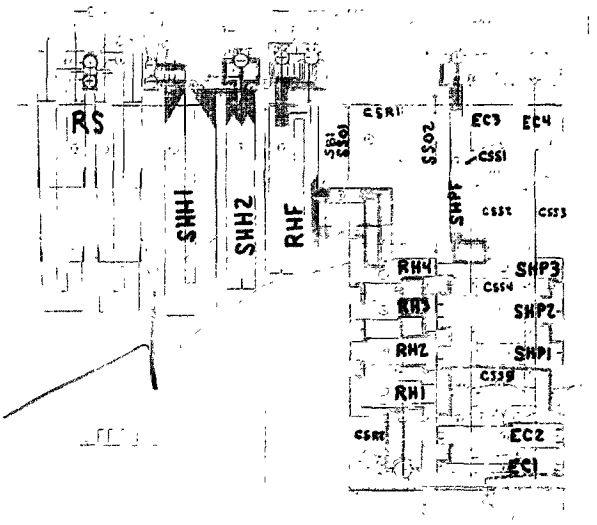
Boiler Heating Surface Sketch



FELT Point.

Different Bundles for Modeling.

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Math Model Geometry

	EC1	EC2	EC3	EC4	SHP1	SHP2	SHP3	SHPF	RS	SHH1
SL (in) longitudinal sp	2.75	2 75	-	-	2 75	2 75	2 75	3	2.25	2.5
ST (in) transverse sp	6	6	24	24	6	6	6	12	54	24
tube O. D. (in)	2	2	2.75	2.75	2	2	2	2.25	2	2
min. wall (in)	0 203	0.203	0.340	0 340	0.203	0.220	0.220	0.225	multi.	multi
Surface area (ft²)	27,590	53,269	4,055	4,055	63,935	71,998	47,937	20,258	22,016	36,592
Mod. Surface Area (ft²)	27,590	53,269	4,055	4,055	63,935	71,998	47,937	20,258	25,451	36,592
No Elements	170	170	42	42	168	168	168	84	16	84
No. Rows	12	24	1	1	24	30	21	12	88	30
No. Tubes/element	3	3	1	1	6	6	6	12	22	15
No Circuits	510	510	42	42	1008	1008	1008	1008	704	1260

	SHH2	RH1	RH2	RH3	RH4	RHF	SB1	SS01	SS02
SL (in) longitudinal sp	2 5	3 25	3.25	3 25	3.25	3.25/2 75	3.25	3	3
ST (in) transverse sp	12	6	6	6	6	9	9	12	12
tube O. D. (in)	1 75	2.5	2.5	2.5	2 5	multi.	2.75	2 75	2.75
min. wall (in)	multi.	0.180	0.180	0 180	0.180	multi.	0.220	0.220	0.220
Surface area (ft²)	45,360	62,270	47,930	33,871	36,339	99,739	8,482	2,203	2,203
Design Surface Area (ft²)	45,360	62,270	47,930	33,871	36,339	99,739	8,482	2,203	2,203
No. Elements	84	170	170	170	170	113	85	85	85
No. Rows	30	29	22	16	21	36	3	3	3
No. Tubes/element	15	8	8	8	8	12	3	3	3
No Circuits	1260	1360	1360	1360	1360	1360	255	255	255

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Effectiveness Factor

Textbook equation

Part of the calibration methods.

Q=Uo×A×LMTD

- Q = Heat absorbed by bundle (Btu/hr)
- Uo = Empirical Heat transfer Coefficient (Btu/hr-ft²-°F)
- A = Area (ft²)
- LMTD = Log Mean Temperature Difference (°F)

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Effectiveness Factor

Q=Uo×A×LMTD Basic heat transfer equation

- Q = Heat absorbed by bundle (Btu/hr)
- Uo = Empirical Heat transfer Coefficient (Btu/hr-ft²-°F)
- A = Area (ft²)
- LMTD = Log Mean Temperature Difference (°F)

Q=Fa×Ca×Cs×Cf×Uo×A×LMTD Basic heat transfer equation with correction factors applied

- Fa = arrangement factor - geometry correction
- Ca = gas angle correction factor
- Cs = gas stratification correction factor
- Cf = fouling factor

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Effectiveness Factor

$Q=Uo \times A \times LMTD$ Basic heat transfer equation

- **Q = Heat absorbed by bundle (Btu/hr)**
- **Uo = Empirical Heat transfer Coefficient (Btu/hr-ft²-°F)**
- **A = Area (ft²)**
- **LMTD = Log Mean Temperature Difference (°F)**

$Q=Fa \times Ca \times Cs \times Cf \times Uo \times A \times LMTD$ Basic heat transfer equation with correction factors applied

- **Fa = arrangement factor - geometry correction**
- **Ca = gas angle correction factor**
- **Cs = gas stratification correction factor**
- ***Cf = fouling factor***

$Q=BE \times Fa \times Ca \times Cs \times Cf \times Uo \times A \times LMTD$ Basic heat transfer equation with correction & effectiveness factors applied

BE = bundle effectiveness factor

Allows predicted theoretical heat transfer to be adjusted to match actual test data

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Math Model Summary

	Units	Test 1	Model 1	Test 2	Model 2
MW		900	**900**	900	**900**
Fuel	lbm/hr	Coal	**Coal**	Coal	**Coal**
Excess Air	%	13 86	**13.86**	13 31	**13.31**
Feedwater flow	lbm/hr	6,214,290	**6,214,202**	6,263,947	**6,263,512**
Main steam flow	lbm/hr	6,285,545	**6,285,545**	6,310,995	**6,310,995**
Reheat steam flow	lbm/hr	5,146,618	**5,146,618**	5,166,006	**5,166,006**
Superheater spray flow 1st stage	lbm/hr	12,606	**12,694**	12,507	**12,942**
Superheater spray flow 2nd stage	lbm/hr	58,649	**58,649**	34,541	**34,541**
Reheat spray flow	lbm/hr	0	**0**	0	
Flue gas flow split	%SH/RH	73.1/26.9	**73.1/26.9**	69/31	**69/31**
Total flue gas flow	lbm/hr	7,461,548	**7,461,548**	7,425,841	**7,425,841**
Total fuel flow	lbm/hr	633,153	**633,153**	632,949	**632,949**
Superheat spray temp	°F	345	**345**	345	**345**
Avg. Econ water inlet temp.	°F	544	**544**	544	**544**
Avg. Econ water outlet temp	°F	576	**576**	576	**576**
PSH before spray temp	°F	723	**722**	719	**718**
PSH after spray temp	°F	721	**721**	717	**717**
SSH before spray temp	°F	789	**789**	782	**782**
SSH after spray temp	°F	779	**779**	776	**776**
SSH inlet bank outlet temp	°F	922	**922**	922	**922**
Main SH outlet temp	°F	1005	**1005**	1005	**1005**
Reheat inlet temp	°F	633	**633**	633	**633**
Reheat outlet temp	°F	1003	**1003**	996	**996**

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Math Model Summary (cont.)

	Units	Test 1	Model 1	Test 2	Model 2
MW		900	**900**	900	**900**
Fuel	lbm/hr	Coal	**Coal**	Coal	**Coal**
Excess Air	%	13 86	**13.86**	13 31	**13.31**
Economizer inlet pressure	psia	2626	**2626**	2628	**2628**
Drum pressure	psia	2544	**2544**	2546	**2546**
Superheater outlet pressure	psia	2263	**2263**	2263	**2263**
Reheat inlet pressure	psia	574	**574**	574	**574**
Reheat outlet pressure	psia	540	**540**	541	**541**
Furnace Exit Gas Temp	°F	2217	**2217**	2212	**2212**
Economizer exit gas temp , avg.	°F	742	**742**	739	**739**
Airheater outlet gas temp , uncorr.	°F	332	**332**	330	**330**
Airheater inlet air temp	°F	102	**102**	101	**101**
Airheater outlet air temp	°F	621	**621**	619	**619**
Furnace EPRS Heat release	Btu/hr-ft²	96,121	**96,121**	96,008	**96,008**
Radiant SH Q/A	Btu/hr-ft²	23,200	**23,200**	23,150	**23,160**

Part of Calibration

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Math Model Summary (cont.)

	Units	Test 3	Model 3	Test 4	Model 4
MW		900	**900**	950	**950**
Fuel	lbm/hr	Coal	**Coal**	Coal	**Coal**
Excess Air	%	12.05	**12.05**	14.86	**14.86**
Feedwater flow	lbm/hr	6,186,240	**6,186,172**	6,723,341	**6,723,319**
Main steam flow	lbm/hr	6,237,785	**6,237,785**	6,743,404	**6,743,404**
Reheat steam flow	lbm/hr	5,110,235	**5,110,235**	5,494,398	**5,494,398**
Superheater spray flow 1st stage	lbm/hr	12,449	**12,517**	3,080	**3,102**
Superheater spray flow 2nd stage	lbm/hr	39,096	**39,096**	16,893	**16,893**
Reheat spray flow	lbm/hr	0	**0**	0	**0**
Flue gas flow split	%SH/RH	71/29	**71/29**	71/29	**71/29**
Total flue gas flow	lbm/hr	7,313,758	**7,313,758**	7,652,368	**7,652,368**
Total fuel flow	lbm/hr	629,857	**629,857**	672,346	**672,346**
Superheat spray temp	°F	345	**345**	349	**349**
Avg. Econ water inlet temp.	°F	544	**544**	549	**549**
Avg. Econ water outlet temp	°F	576	**576**	581	**581**
PSH before spray temp	°F	723	**722**	722	**722**
PSH after spray temp	°F	721	**720**	721	**721.8**
SSH before spray temp	°F	787	**787**	782	**783**
SSH after spray temp	°F	778	**778**	779	**780**
SSH inlet bank outlet temp	°F	921	**921**	902	**902**
Main SH outlet temp	°F	1005	**1005**	999	**999**
Reheat inlet temp	°F	633	**633**	630	**630**
Reheat outlet temp	°F	1009	**1009**	1004	**1004**

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Math Model Summary (cont.)

	Units	Test 3	Model 3	Test 4	Model 4
MW		900	**900**	950	**950**
Fuel	lbm/hr	Coal	**Coal**	Coal	**Coal**
Excess Air	%	12.05	**12.05**	14.86	**14.86**
Economizer inlet pressure	psia	2623	**2623**	2760	**2760**
Drum pressure	psia	2542	**2542**	2669	**2669**
Superheater outlet pressure	psia	2264	**2264**	2360	**2360**
Reheat inlet pressure	psia	574	**574**	606	**606**
Reheat outlet pressure	psia	539	**539**	571	**571**
Furnace Exit Gas Temp	°F	2242	**2242**	2247	**2247**
Economizer exit gas temp , avg	°F	753	**753**	749	**749**
Airheater outlet gas temp., uncorr	°F	329	**329**	319	**319**
Airheater inlet air temp	°F	94	**94**	99	**99**
Airheater outlet air temp	°F	629	**629**	622	**622**
Furnace EPRS Heat release	Btu/hr-ft²	95,613	**95,613**	101,889	**101,889**
Radiant SH Q/A	Btu/hr-ft²	23,000	**23,000**	24,840	**24,840**

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Effectiveness Factors

	Units	Test 1	Test 2	Test 3	Test 4
MW		900	900	900	950
SHH1	-	1.2	1.25	1.18	1 08
SHH2	-	0.73	0 75	0.721	0.86
RHF	-	0.83	0.81	0.8	0.84
RH4	-	0 82	0 81	0.805	0.84
RH3	-	0.82	0 81	0.81	0.84
RH2	-	0.82	0.81	0.81	0.84
RH1	-	0.82	0 81	0.81	0 84
SHPF	-	0.95	0.91	0.89	0.925
SH3	-	0.95	0.92	0.89	0.925
SH2	-	0.95	0 92	0.888	0.925
SH1	-	0 95	0 92	0 885	0.925
EC1	-	1.06	1 14	1.0	1.13
EC2	-	1.06	1.14	1.0	1 13

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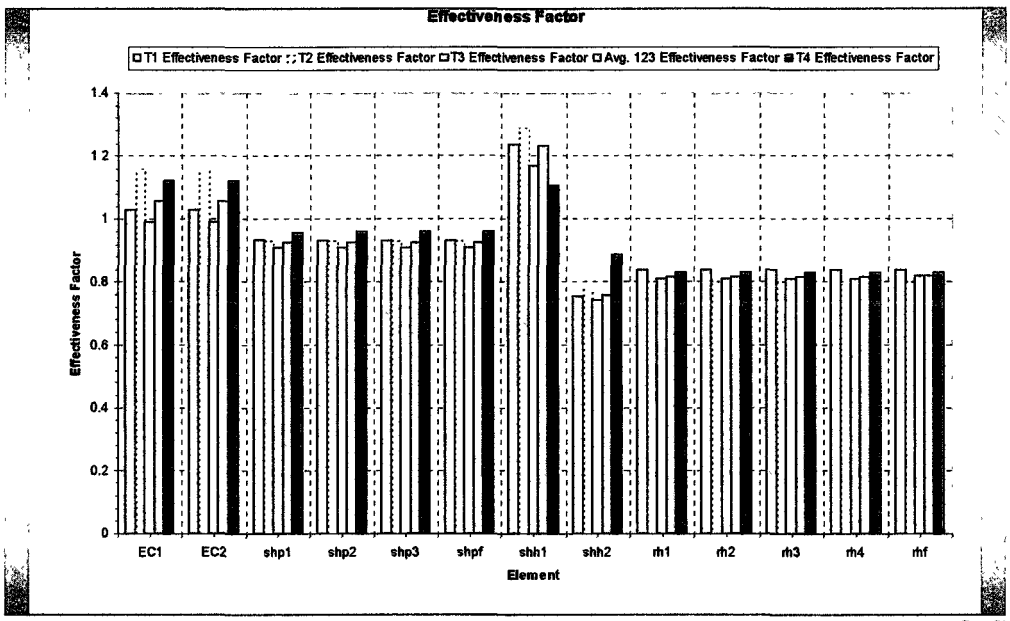

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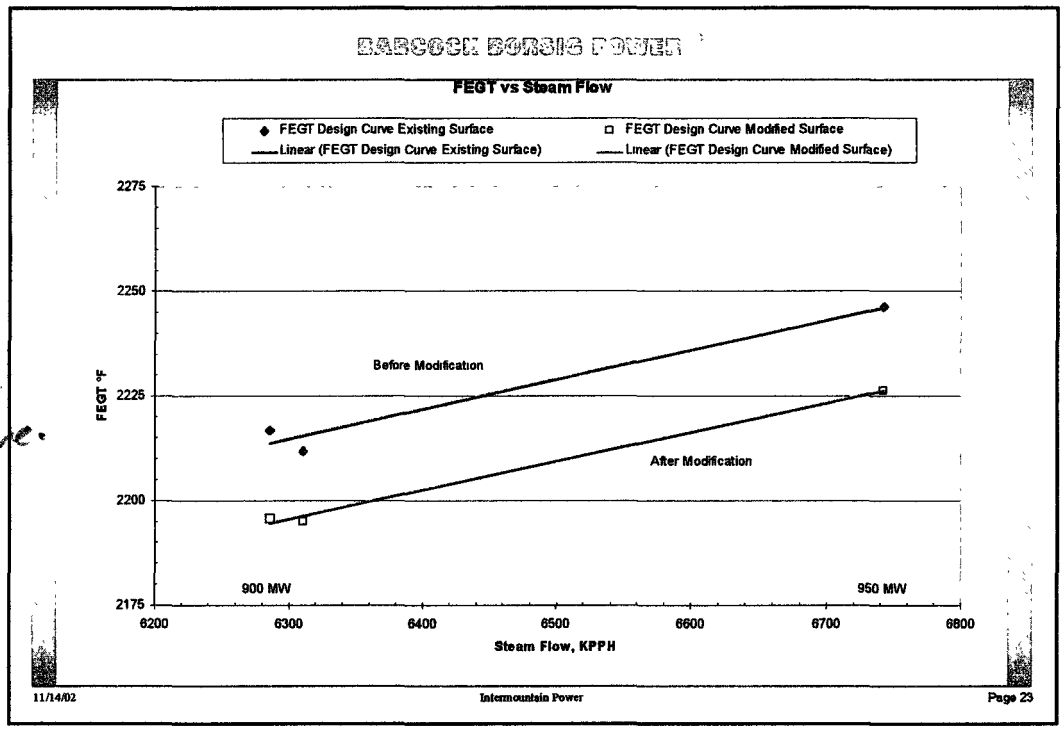
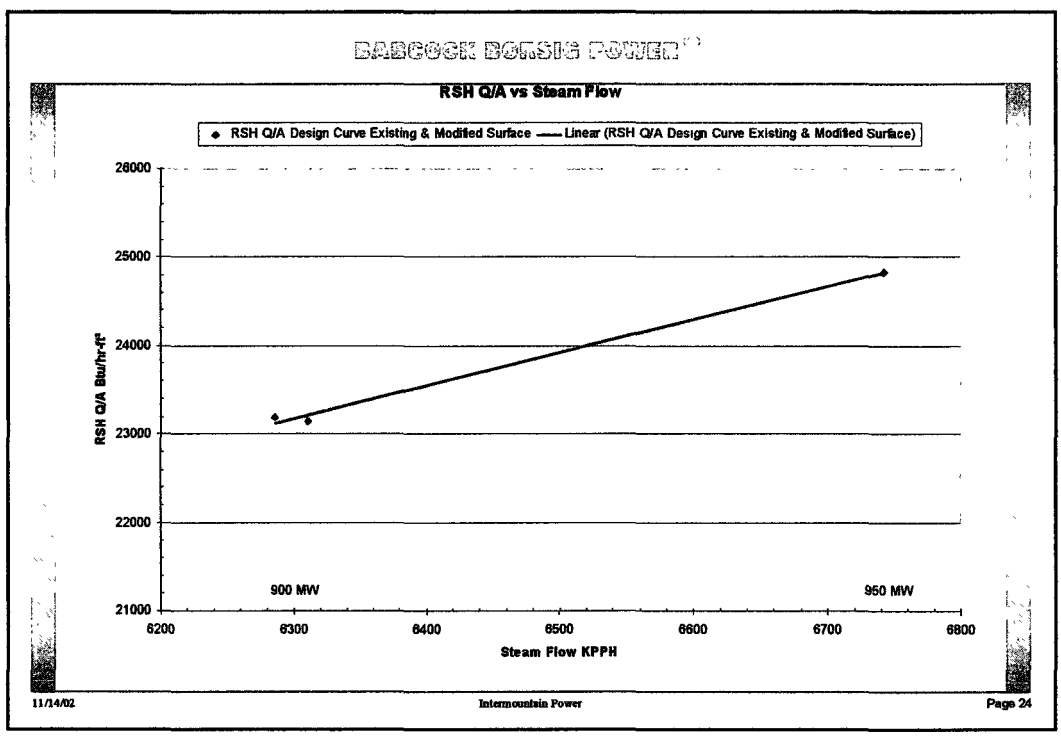
Modified Radiant Superheater

Extending the pendants by 8'

Furnace Exit Gas Temperature.





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Predicted Performance Summary 900 MW

	Units	No Surface Change	New Surface @ 13.5% Excess Air	New Surface @ 18% Excess Air
MW		900	900	900
Fuel	lbm/hr	Coal	Coal	Coal
Excess Air	%	13 5	13 5	18
Feedwater flow	lbm/hr	6,225,115	6,173,379	6,071,110
Main steam flow	lbm/hr	6,285,545	6,285,545	6,285,545
Reheat steam flow	lbm/hr	5,146,618	5,146,618	5,146,618
Total Superheater spray flow	lbm/hr	60,430	112,166	214,435
Reheat spray flow	lbm/hr	0	0	0
Flue gas flow split	%SH/RH	69.8/30.2	68 6/31.4	72.4/27.6
Total flue gas flow	lbm/hr	7,451,161	7,464,168	7,781,395
Total fuel flow	lbm/hr	634,124	637,387	641,019
Econ water inlet temp.	°F	544	544	544
Econ water outlet temp	°F	576	575	579
Main SH outlet temp	°F	1005	1005	1005
Reheat inlet temp	°F	633	633	633
Reheat outlet temp	°F	1005	1005	1005

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Predicted Performance Summary 900 MW

	Units	No Surface Change	New Surface @ 13.5% Excess Air	New Surface @ 18% Excess Air
MW		900	900	900
Fuel	lbm/hr	Coal	Coal	Coal
Excess Air	%	13.5	13 5	18
Economizer inlet pressure	psia	2626	2645	2645
Drum pressure	psia	2544	2549	2549
Superheater outlet pressure	psia	2263	2263	2263
Reheat inlet pressure	psia	579	579	579
Reheat outlet pressure	psia	540	540	540
Furnace Exit Gas Temp	°F	2215	2197	2184
Economizer exit gas temp , avg.	°F	742	742	746
Airheater outlet gas temp , uncorr.	°F	317	317	318
Airheater inlet air temp	°F	80	80	80
Airheater outlet air temp	°F	620	620	624
Furnace EPRS Heat release	Btu/hr-ft^2	96,259	92,902	93,934
Radiant SH Q/A	Btu/hr-ft^2	23,230	23,278	23,564

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Predicted Performance Summary 950 MW

	Units	No Surface Change	New Surface @ 13.5% Excess Air	New Surface @ 18% Excess Air
MW		950	950	950
Fuel	lbm/hr	Coal	Coal	Coal
Excess Air	%	13 5	13 5	18
Feedwater flow	lbm/hr	6,750,000	6,730,364	6,607,027
Main steam flow	lbm/hr	6,750,000	6,750,000	6,750,000
Reheat steam flow	lbm/hr	5,494,398	5,494,398	5,494,398
Total Superheater spray flow	lbm/hr	0	19,636	142,973
Reheat spray flow	*lbm/hr*	*0*	*0*	*0*
Flue gas flow split	%SH/RH	69.6/30.4	69.9/30.1	73 8/26 2
Total flue gas flow	lbm/hr	7,906,588	7,931,749	8,277,683
Total fuel flow	lbm/hr	675,166	677,315	681,902
Econ water inlet temp	°F	549	549	549
Econ water outlet temp.	°F	580	580	584
Main SH outlet temp	°F	998	1005	1005
Reheat inlet temp	°F	629	634	634
Reheat outlet temp	°F	1003	1005	1005

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Predicted Performance Summary 950 MW

	Units	No Surface Change	New Surface @ 13.5% Excess Air	New Surface @ 18% Excess Air
MW		950	950	950
Fuel	lbm/hr	Coal	Coal	Coal
Excess Air	%	13.5	13.5	18
Economizer inlet pressure	psia	2764	2775	2775
Drum pressure	psia	2669	2675	2675
Superheater outlet pressure	psia	2360	2360	2360
Reheat inlet pressure	psia	606	606	606
Reheat outlet pressure	psia	571	571	571
Furnace Exit Gas Temp	°F	2247	2229	2218
Economizer exit gas temp., avg.	°F	753	755	759
Airheater outlet gas temp., uncorr.	°F	322	322	325
Airheater inlet air temp	°F	80	80	80
Airheater outlet air temp	°F	625	625	629
Furnace EPRS Heat release	Btu/hr-ft²	102,228	98,829	100,032
Radiant SH Q/A	Btu/hr-ft²	24,937	24,917	25,250

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Pressure Drop

	Units	Test Data	Existing Design	After Mod	Test Data	Existing Design	After Mod
MW	MW	900	900	900	950	950	950
Steam Flow	KPPH	6,286	6,286	6,286	6,750	6,750	6,750
Radiant Superheater pressure drop	psi	28	29 89	35.32	29	34.48	40.45
Pressure drop increase	psi	-	-	5 4	-	-	6 0
Superheater outlet pressure	psig	2248	2248	2248	2345	2345	2345
Drum pressure	psig	2529	2529	2534 4	2654	2654	2660
Total superheater pressure drop	psi	281	281	286.4	309	309	315
Maximum allowable working pressure (MAWP)	psig	2975	2975	2975	2975	2975	2975
Margin Drum pressure to MAWP	%	14 99	14 99	14.81	10.79	10.79	10.59

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Metal Studies

Purpose:

Ensure proper selection of tube material and wall thickness

Criteria:

Meet ASME Section 1 Code Requirements

Ensure operating temperatures are below material oxidation limits

Method:

Output from heat transfer model used to calculate average and outside tube metal temperatures

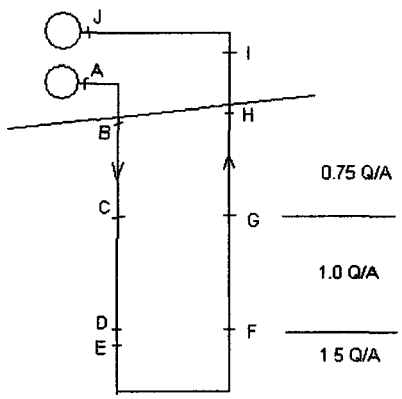
Margins applied:

Steam Temperature Unbalance

Heat Flux Profile

BABCOCK BORSIG POWER

Radiant Superheater Metal Studies

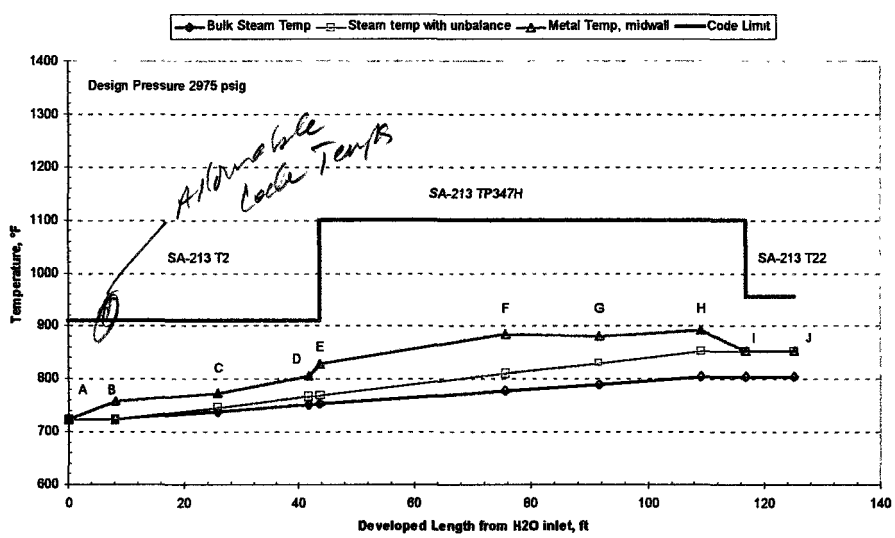


Temperatures

A-B 2 × 0.220 T2
B-C 2 × 0.220 T2
C-D 2 × 0.220 T2
D-E 2 × 0.220 T2
E-F 2 × 0.203 TP347H
F-G 2 × 0.203 TP347H
G-H 2 × 0.203 TP347H
H-I 2 × 0 203 TP347H
I-J 2 × 0 260 T22

BABCOCK BORSIG POWER

Tube Metal Calculations New Radiant Superheater
ASME Code Limit



Questions and Discussion

BABCOCK BORSIG POWER	Engineering Standard - Boiler Systems Title Tube Metal Design Procedures Tube Materials, Design Limits, and Typical Ordered Wall Thicknesses				
Issued by	Approved by	Revision	Date	Page	Guideline
B. Vitalis	K. Toupin	2	September 11, 2002	1 of 2	**MS-03**

ASME Designation	General Use (note 1): Econ	Boiler Bank	WaterWall	LTSH	LTRH	Radiant SH/RH	HTSH/HTRH	HT Corrosive	Max Temp (outside surface), °F	Alloy Type	Form (note 2)	Composition, % by weight: C	Si	Mn	P	S	Cr	Ni	Mo	Ti	Cu	Al
SA-178 A	■	■	■						850	Low Carbon	ERW	0 06-0 18		0 27-0 63	0 035 max	0 035 max						
SA-178 C	■	■	■						850	Low Carbon	ERW	0 35 max		0 80 max	0 035 max	0 035 max						
SA-192	■	■	■						850	Medium Carbon	S	0 35 max	0 25 max	0 80 max	0 035 max	0 035 max						
SA-210 A1	■	■	■	■					850	Medium Carbon	S	0 27 max	0 10 max	0 93 max	0 035 max	0 035 max						
SA-210 C	■	■	■	■					850	Medium Carbon	S	0 35 max	0 10 max	0 29-1 06	0 035 max	0 035 max						
SA-209 T1				■					900	Carbon Moly	S	0 10-0 20	0 10-0 50	0 30-0 80	0 025 max	0 025 max			0 44-0 65			
SA-209 T1A				■					900	Carbon Moly	S	0 15-0 25		0 30-0 80	0 025 max	0 025 max			0 44-0 65			
SA-213 T2				■					975	Carbon Moly	S	0 10-0 20	0 10-0 30	0 30-0 61	0 025 max	0 025 max	0 50-0 81		0 44-0 65			
SA-213 T11				■	■				1025	Chrome Moly	S	0 05-0 15	0 50-1 00	0 30-0 60	0 025 max	0 025 max	1 0-1 50		0 44-0 65			
SA-213 T12				■	■				1025	Chrome Moly	S	0 05-0 15	0 50 max	0 30-0 61	0 025 max	0 025 max	0 80-1 25		0 44-0 65			
SA-213 T22						■	■		1075 *	Chrome Moly	S	0 05-0 15	0 50 max	0 30-0 60	0 025 max	0 025 max	1 9-2 6		0 87-1 13			
SA-213 T91						■	■		1200	Chrome Moly	S	0 08-0 12	0 20-0 50	0 30-0 60	0 20 max	0 010 max	8 0-9 50		0 85-1 05			
SA-213 TP304H						■	■		1300	Austenitic Stainless	S	0 04-0 10	0 75 max	2 0 max	0 04 max	0 03 max	18 0-20 0	8 0-11 0				
SA-213 TP310H							■	■	1300	Austenitic Stainless	S	0 04-0.10	0 75 max	2 0 max	0 04 max	0 03 max	24 0-26 0	19 0-22 0				
SA-213 TP316H						■	■		1300	Austenitic Stainless	S	0 04-0 10	0 75 max	2 0 max	0 04 max	0 03 max	16 0-18 0	11 0-14 0	2 0-3 0			
SA-213 TP321H						■	■		1300	Austenitic Stainless	S	0 04-0 10	0 75 max	2 0 max	0 04 max	0 03 max	17 0-20 0	9 0-13 0				
SA-213 TP347H						■	■		1300	Austenitic Stainless	S	0 04-0 10	0 75 max	2 0 max	0 04 max	0 03 max	17 0-20 0	9 0-13 0				
SB-515 800 erw								■	1300	800 Series, *Incoloy*	ERW	0 02	0 35	1 00	0 02	0 01	21 0	32 0		0 40	0 30	0 40
SB-407 800								■	1300	800 Series, *Incoloy*	S	0 02	0 35	1 00	0 02	0 01	21 0	32 0		0 40	0 30	0 40
SB-407 800H								■	1300	800 Series, *Incoloy*	S	0 08	0 35	1 00	0 02	0 01	21 0	32 0		0 40	0 30	0 40
SB-407 800HT								■	1300	800 Series, *Incoloy*	S	0 08	0 35	1 00	0 02	0 01	21 0	32 0		0 40	0 30	0 40

Notes:

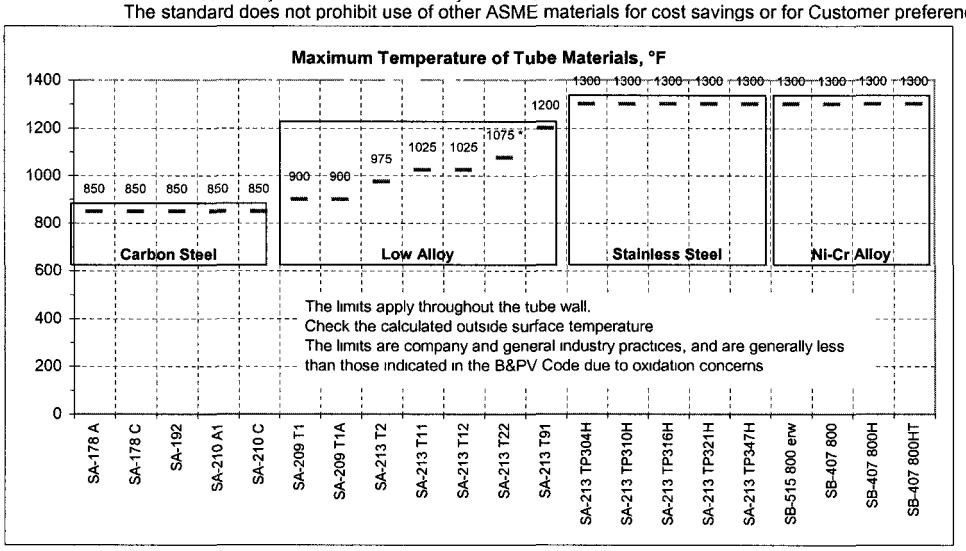
1 The locations indicated for use (by shading) are typical Materials may be used in other areas

2 Tube form ERW = Electric Resistance Welded (longitudinal seam), S = Seamless tube.
For specific information regarding cold- and hot-finished tubing, refer to Section MS-18.

3 The general use and maximum temperature limits apply to all fuels except refuse / municipal solid waste
For RDF/MSW application guidelines, refer to Section MS-17

* For SA-213 T22, the maximum allowable temperature is increased to 1100°F for tubing outside of the gas stream (inside penthouse).

4 This is a summary of the most commonly used materials.
The standard does not prohibit use of other ASME materials for cost savings or for Customer preference



Typical Ordered Wall Thicknesses

See notes at bottom of page

US Size Typical: US std. inch	*SI equiv mm*	SI Typical: *US equiv inch*	SI std mm
0 095	*2 41*	*0 063*	1 6
0 105	*2 67*	*0.079*	2 0
0 110	*2.79*	*0.091*	2 3
0 125	*3.18*	*0.102*	2 6
0 135	*3.43*	*0.114*	2 9
0 150	*3.81*	*0.126*	3 2
0 156	*3.96*	*0.138*	3 5
0 165	*4.19*	*0.157*	4 0
0 180	*4.57*	*0 177*	4 5
0 188	*4.78*	*0.197*	5 0
0 200	*5.08*	*0.217*	5 5
0 203	*5.16*	*0.236*	6 0
0 220	*5.59*	*0.256*	6 5
0 240	*6.10*	*0.276*	7 0
0 250	*6.35*	*0.295*	7 5
0 260	*6.60*	*0.315*	8 0
0 280	*7.11*	*0.335*	8 5
0 284	*7.21*	*0 354*	9 0
0.300	*7.62*	*0.374*	9 5
0 313	*7.95*	*0 394*	10 0
0 320	*8.13*	*0.413*	10 5
0 340	*8.64*	*0 433*	11 0
0.360	*9.14*	*0 453*	11 5
0 375	*9.53*	*0 472*	12 0
0.400	*10 16*	*0.492*	12 5
0 420	*10.67*		
0 438	*11.13*		
0 460	*11.68*		
0 480	*12.19*		
0 500	*12 70*		

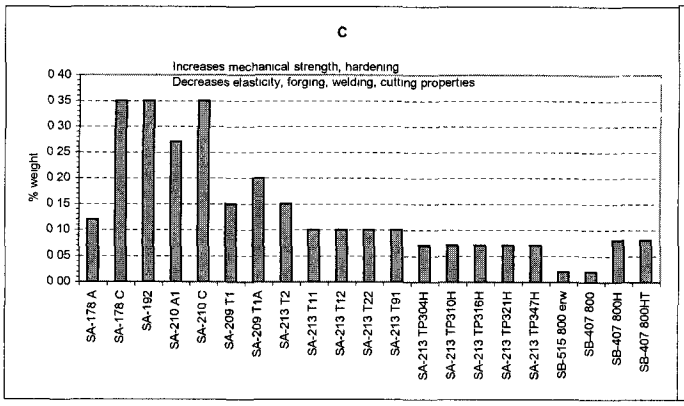
Source B&W Tubular Products Division Pricing Schedule

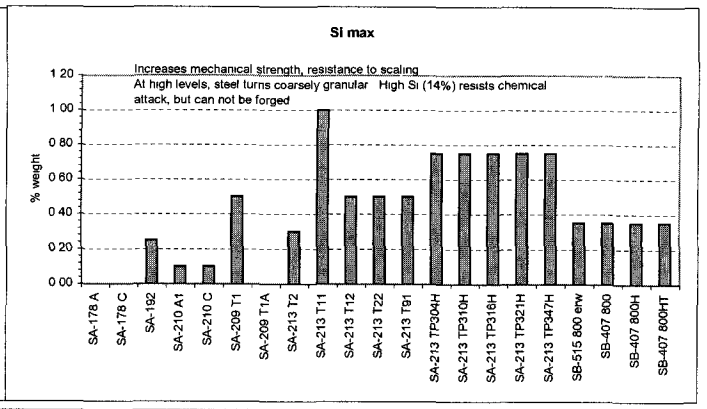
Source Sumitomo Metal Industries, Ltd

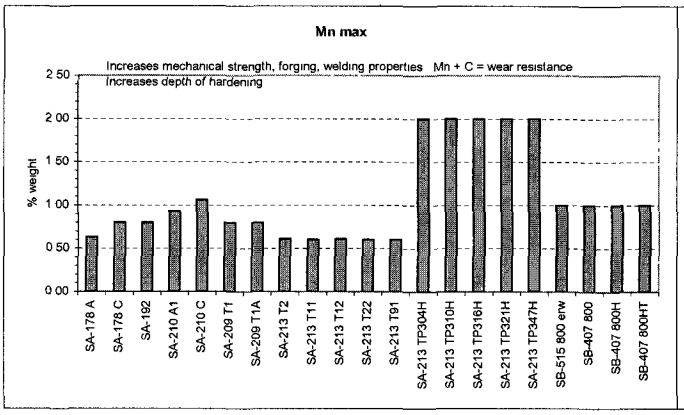
Ordering a typical wall thickness may have the following advantages:
- Size may be stocked by several suppliers. [availability, schedule, price competition]
- Size may not require a special mill run. [same as above]
- Replacement parts are more readily available due to the above.
- Boiler performance calculations may be performed with final sizes

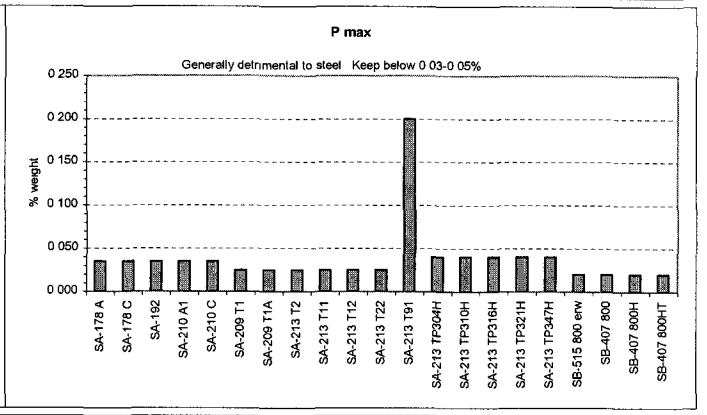
Notes regarding ordering special wall thicknesses:
- If adequate lead time and quantity for a mill run, pricing may be competitive for the special thickness
- Potential cost savings by ordering only the metal required
- Potential pressure drop reduction with reduced wall

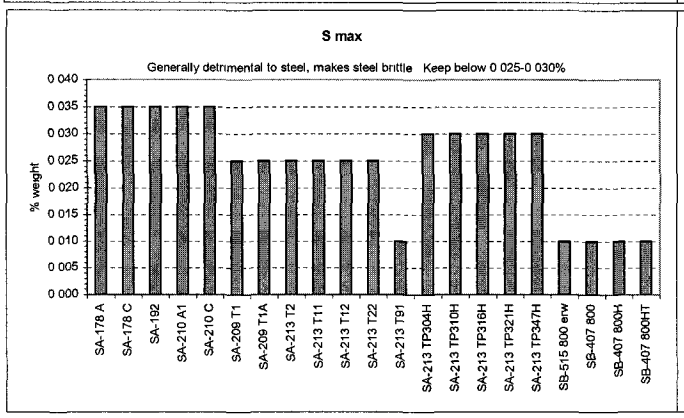
GENERAL PRACTICE: BOILER DESIGN PERFORMS CALCULATIONS WITH, AND SPECIFIES, STANDARD THICKNESSES. EXCEPTIONS MAY BE MADE.

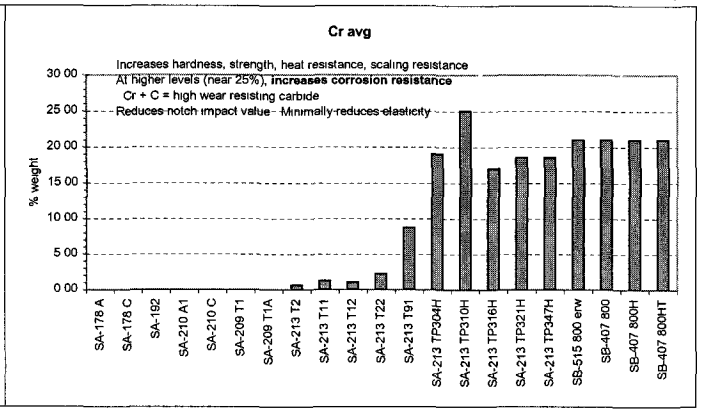

C
Increases mechanical strength, hardening
Decreases elasticity, forging, welding, cutting properties
% weight
SA-178 A
SA-178 C
SA-192
SA-210 A1
SA-210 C
SA-209 T1
SA-209 T1A
SA-213 T2
SA-213 T11
SA-213 T12
SA-213 T22
SA-213 T91
SA-213 TP304H
SA-213 TP310H
SA-213 TP316H
SA-213 TP321H
SA-213 TP347H
SB-515 800 erw
SB-407 800
SB-407 800H
SB-407 800HT

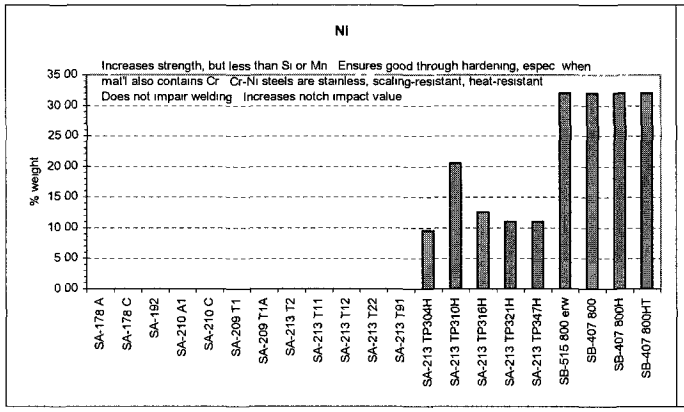

Si max
Increases mechanical strength, resistance to scaling
At high levels, steel turns coarsely granular High Si (14%) resists chemical attack, but can not be forged
% weight
SA-178 A
SA-178 C
SA-192
SA-210 A1
SA-210 C
SA-209 T1
SA-209 T1A
SA-213 T2
SA-213 T11
SA-213 T12
SA-213 T22
SA-213 T91
SA-213 TP304H
SA-213 TP310H
SA-213 TP316H
SA-213 TP321H
SA-213 TP347H
SB-515 800 erw
SB-407 800
SB-407 800H
SB-407 800HT

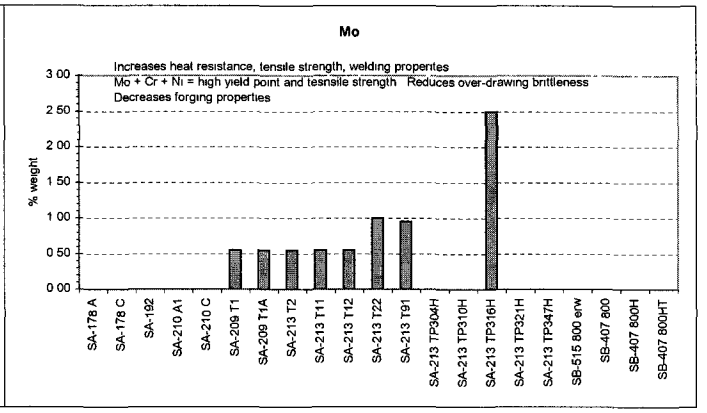

Mn max
Increases mechanical strength, forging, welding properties Mn + C = wear resistance
Increases depth of hardening
% weight
SA-178 A
SA-178 C
SA-192
SA-210 A1
SA-210 C
SA-209 T1
SA-209 T1A
SA-213 T2
SA-213 T11
SA-213 T12
SA-213 T22
SA-213 T91
SA-213 TP304H
SA-213 TP310H
SA-213 TP316H
SA-213 TP321H
SA-213 TP347H
SB-515 800 erw
SB-407 800
SB-407 800H
SB-407 800HT


P max
Generally detrimental to steel Keep below 0 03-0 05%
% weight
SA-178 A
SA-178 C
SA-192
SA-210 A1
SA-210 C
SA-209 T1
SA-209 T1A
SA-213 T2
SA-213 T11
SA-213 T12
SA-213 T22
SA-213 T91
SA-213 TP304H
SA-213 TP310H
SA-213 TP316H
SA-213 TP321H
SA-213 TP347H
SB-515 800 erw
SB-407 800
SB-407 800H
SB-407 800HT


S max
Generally detrimental to steel, makes steel brittle Keep below 0 025-0 030%
% weight
SA-178 A
SA-178 C
SA-192
SA-210 A1
SA-210 C
SA-209 T1
SA-209 T1A
SA-213 T2
SA-213 T11
SA-213 T12
SA-213 T22
SA-213 T91
SA-213 TP304H
SA-213 TP310H
SA-213 TP316H
SA-213 TP321H
SA-213 TP347H
SB-515 800 erw
SB-407 800
SB-407 800H
SB-407 800HT


Cr avg
Increases hardness, strength, heat resistance, scaling resistance
At higher levels (near 25%), increases corrosion resistance
Cr + C = high wear resisting carbide
Reduces notch impact value Minimally reduces elasticity
% weight
SA-178 A
SA-178 C
SA-192
SA-210 A1
SA-210 C
SA-209 T1
SA-209 T1A
SA-213 T2
SA-213 T11
SA-213 T12
SA-213 T22
SA-213 T91
SA-213 TP304H
SA-213 TP310H
SA-213 TP316H
SA-213 TP321H
SA-213 TP347H
SB-515 800 erw
SB-407 800
SB-407 800H
SB-407 800HT


Ni
Increases strength, but less than Si or Mn Ensures good through hardening, espec when mat'l also contains Cr Cr-Ni steels are stainless, scaling-resistant, heat-resistant
Does not impair welding Increases notch impact value
% weight
SA-178 A
SA-178 C
SA-192
SA-210 A1
SA-210 C
SA-209 T1
SA-209 T1A
SA-213 T2
SA-213 T11
SA-213 T12
SA-213 T22
SA-213 T91
SA-213 TP304H
SA-213 TP310H
SA-213 TP316H
SA-213 TP321H
SA-213 TP347H
SB-515 800 erw
SB-407 800
SB-407 800H
SB-407 800HT


Mo
Increases heat resistance, tensile strength, welding properties
Mo + Cr + Ni = high yield point and tesnsile strength Reduces over-drawing brittleness
Decreases forging properties
% weight
SA-178 A
SA-178 C
SA-192
SA-210 A1
SA-210 C
SA-209 T1
SA-209 T1A
SA-213 T2
SA-213 T11
SA-213 T12
SA-213 T22
SA-213 T91
SA-213 TP304H
SA-213 TP310H
SA-213 TP316H
SA-213 TP321H
SA-213 TP347H
SB-515 800 erw
SB-407 800
SB-407 800H
SB-407 800HT