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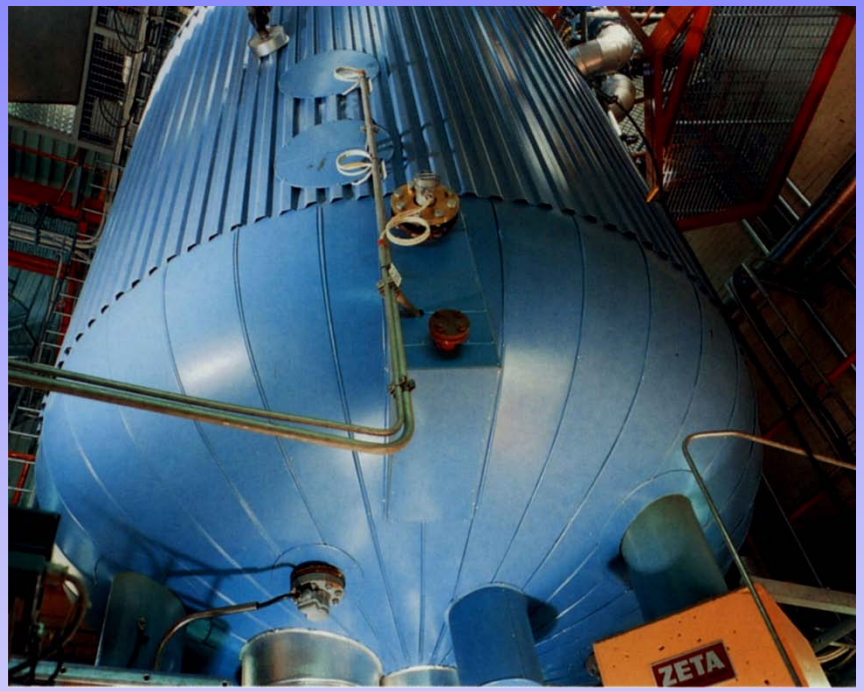
ZANDER & INGESTRÖM

Since 1898

Z&I *"ZETA"* High Voltage Electrode Steam Boiler
Auxiliary Steam Boiler for Power Plants



World's Largest Electrode Steam Boiler
ZETA 67 MW, 13.8kV, 30 bar

France Nogent Nuclear Power Plant
ZETA 2 x 24MW, 6.6kV, 15 bar Aux Boilers

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Presentation Overview

- Z&I Company Overview and History of Electrode Boilers
- ZETA Boilers in Nuclear Power Plants
- Principles of Operation for ZETA Boilers
- Why ZETA Boilers for NPPs

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Company Overview

- Headquarter in Taby, Sweden (Near Stockholm)
- Two divisions: Heat Technology and Pump Solutions
- ISO 9001:2000 Certified for Design, Mfg, and Service

DNV

DET NORSKE VERITAS

MANAGEMENT SYSTEM CERTIFICATE

Certificate no: 2000-SKM-AQ-1376

This is to certify that

THE QUALITY MANAGEMENT SYSTEM

of

Zander & Ingeström AB

STOCKHOLM and HELSINGBORG in SWEDEN

has been found to conform with the Quality Management System Standard

ISO 9001:2000

This Certificate is valid for the following product or service ranges:

SALES AND SERVICE WITHIN OUR BRANDS FLOW- AND HEAT TECHNOLOGY, CONSTRUCTION AND PROJECT MANAGING OF HEATING PLANTS AS WELL AS EDUCATION IN OPERATION & MAINTENANCE OF HEATING PLANTS

Place and date
Stockholm, 2006-07-01

The certificate is valid until
2009-12-31

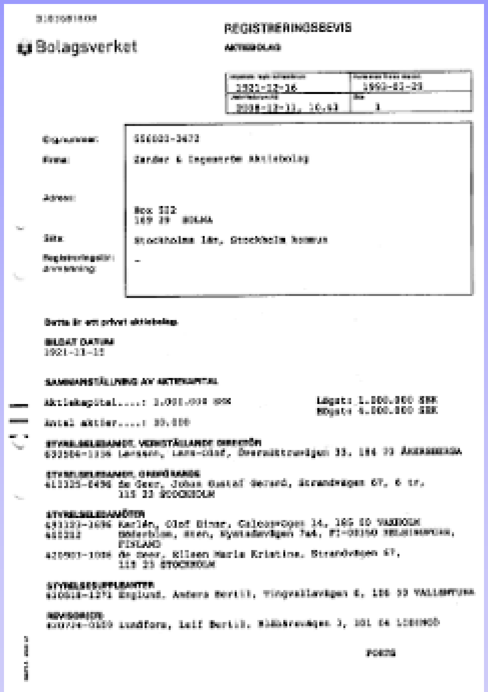
for the Accredited Unit
DNV Certification AB, Sweden

Company initially certificated
1998-05-25

Hans Lindgren
Management Representative

Certification Audit responsible
Tuomo Räsänen
Lead Auditor

ISO 9000



Bolagsverket

REGISTRERINGSBEVIS

BILDAT DATUM
1921-11-15

Swedish Registration

History of Zander & Ingestrom

- Founded in 1898 by Oskar Zander and Bengt Ingestrom
- Bengt Ingestrom is a famous inventor which lived in the 19th century
- Z&I Sweden's 106th Oldest Company

Bengt Ingestrom

- Headquarter in Taby, Sweden (Near Stockholm)
- Two divisions: Heat Technology and Pump Solutions
- ISO 9001:2000 Certified for Design, Mfg, and Service

HQ in Sweden

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History of Z&I ”ZETA” Electrode Boilers

- ” ZETA” Electrode Boilers first built in 1926
- More than 1000 ”ZETA” boilers installed, the most number of Electrode Boilers in the world
- 316 HV-Electrode boilers installed since 1980 (133 steam and 183 water boilers)
- 100% Safety Record over its 83 years history with NO safety incidents in its entire operating history

1930s

1950s

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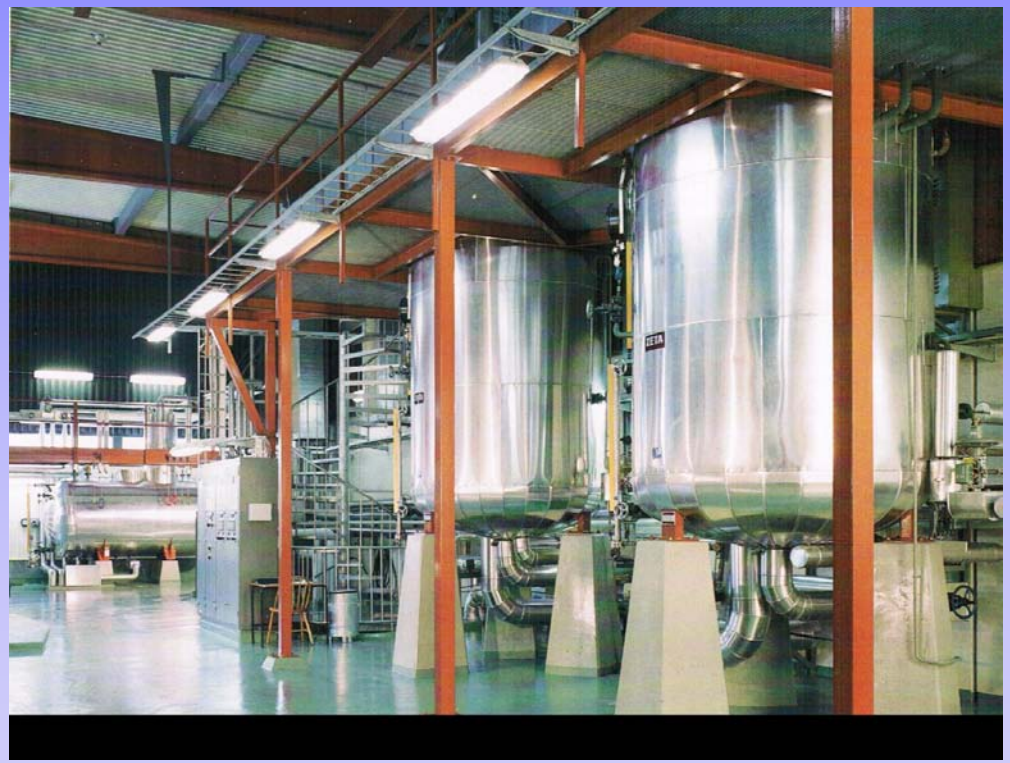
History of Z&I ”ZETA” Electrode Boilers

- Most Number of Electrode Boilers Installed Worldwide
- World’s largest Electrode Boiler (France) – 67MW
- World’s largest Electrode Boiler Plant (Sweden) - 150MW [3 x 50MW]

1970s



Modern ZETA Boiler Plant

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Applications of ZETA Electrode Steam Boilers in Nuclear Power Plants

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Application and Advantages of Electrode Boilers in NPP

- **Application of Auxiliary Boiler in Nuclear Power Plant:**

  Auxiliary Boiler for Nuclear Power Plant is used during start-up or during maintenance of nuclear steam generators to maintain steam pressure and fill steam glands

- **Other alternatives:**

  Some Nuclear Power Plants may choose to use oil-fired boilers to produce steam or use steam piped from another nuclear reactor to supplement steam

- **Advantages for using Electrode Boiler:**
  - No need for oil reservoir, reduced explosion risk, directly connect to medium voltage network of 6-15kV
  - No smoke stack, reduced chance to mistake smoke coming from a nuclear power plant as an explosion
  - Excellent steam quality with low sodium content for reduced wear to steam turbine blades
  - Low maintenance in standby and fast start-up time
  - Electrode Boilers are used as auxiliary boilers in Nuclear Power Plants throughout Europe, USA, Japan, and China

Z&I ZETA Electrode Boilers Nuclear Customer Reference List

	Nuclear Station	Country	Pressure	Voltage	Power
1	Chinon	France	15 bar	6.6kV	2 x 24 MW
2	St Lauren	France	15 bar	6.6kV	2 x 24 MW
3	Bugey	France	15 bar	6.6kV	28MW
4	Saint Alban	France	15 bar	6.6kV	2 x 24MW
5	Tricastin	France	15 bar	6.6kV	2 x 24 MW
6	Gravelines	France	15 bar	6.6kV	2 x 24 MW
7	Super-Phenix (EDF)	France	14 bar	6.6kV	3.6 MW
8	Super-Phenix (Nersa)	France	14 bar	6.6kV	4 x 20MW
9	Paluel	France	15 bar	6.6kV	4 x 24MW
10	Cruas	France	15 bar	6.6kV	2 x 24MW
11	Flamanville	France	15 bar	6.6kV	2 x 24MW
12	Cattenom	France	15 bar	6.6kV	2 x 28MW
13	Dampierre	France	15 bar	6.6kV	2 x 24 MW
14	La Blayais	France	15 bar	6.6kV	2 x 24 MW
15	Nogent	France	15 bar	6.6kV	2 x 24MW
16	Penly	France	15 bar	6.6kV	28MW
17	Golfech	France	15 bar	6.6kV	28MW
18	Belleville	France	15 bar	6.6kV	2 x 24MW
19	Chooz	France	15 bar	6.6kV	28MW
20	Civaux	France	15 bar	6.6kV	28MW
21	Gundremmingen I	Germany	16 bar	10kV	2 x 18MW
22	Biblis	Germany	10 bar	10kV	2 x 16MW
23	Gundremmingen II	Germany	16 bar	10kV	15MW
24	Neckar Westheim I	Germany	16 bar	10kV	26MW
25	Neckar Westheim II	Germany	16 bar	10kV	2 x 16.8MW
26	Kalkar	Germany	16 bar	10kV	2 x 16MW
27	Mulheim-Karlich	Germany	20 bar	10kV	28MW
28	ISAR 2	Germany	16 bar	10kV	2 x 16.8MW
29	Emsland	Germany	16 bar	10kV	2 x 16.8MW
30	Ringhals	Sweden	20 bar	6.6kV	20MW
31	Oskarshamn	Sweden	18 bar	6.6kV	5MW
32	Rongcheng	China	20 bar	6.3kV	1 x 28MW
33	Haiyang	China	20 bar	10kV	2 x 27MW
34	Changjiang, Hainan	China	20 bar	6kV	2 x 27MW

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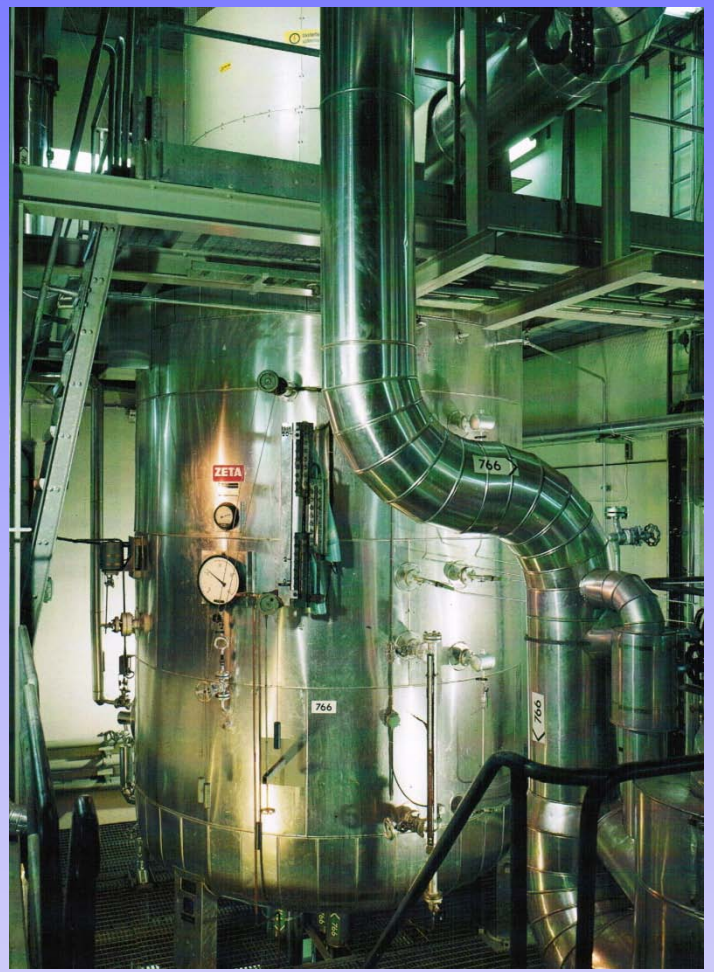
ZETA Boiler used in Sweden NPPs

Ringhals

Oskarshamn



Ringhals – 20MW, 6.6kV

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ZETA Boiler Nuclear Plant Users in France

Bugey

Superphenix

Flamanville

Belleville

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Nogent

Chooz

Cattenom

Penly

Golfech

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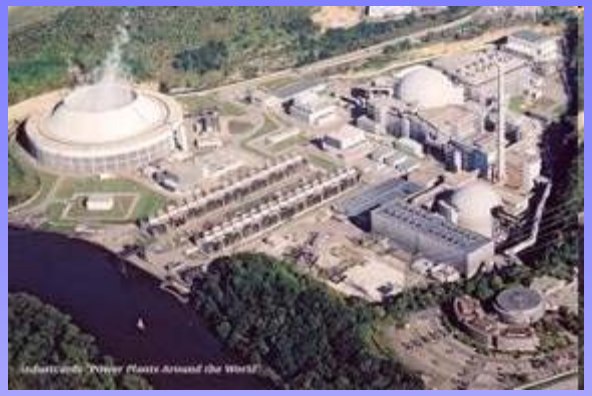
ZETA Boiler Nuclear Plant Users in Germany



Neckar

Mulheim

ISAR

Emsland

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China Nuclear Power References

Haiyang Nuclear Power Plant
2 x 27MW

Rongcheng NPP
1 x 28MW

Hainan Changjiang NPP
2 x 27MW

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Other Applications of ZETA Steam Boilers

Wind Power Plants (Load-balance)

Power Plants (Coal, Oil, Gas fired)

Industrial Factories

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ZETA Electrode Steam Boiler Principles of Operation

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Z&I ZETA Electrode Steam Boiler Specifications

ZDK / ZDKI

- Output: 2 – 70MW
- Voltage: 6 – 15kV
- Op. Press: 10 – 50 bar
- ZDK – Directly earthed neutral
- ZDKI – High-resistance insulated neutral

Astra, Sweden, 12MW, 6kV, 23 bar

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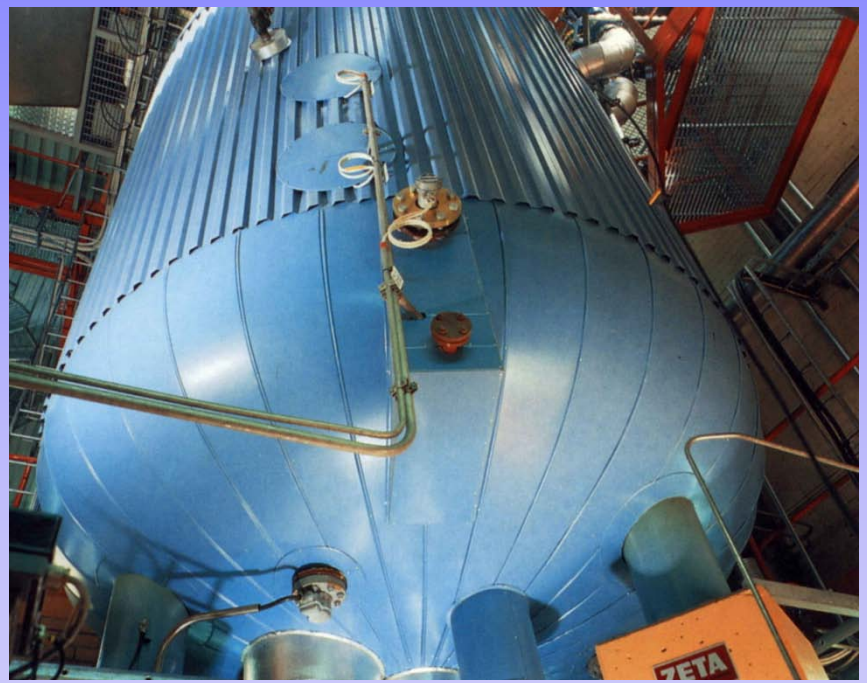
Electrode Steam Vessel Pics



Arjomari papermill, France Steam Boiler
ZETA 67 MW, 13.8kV, 30 bar

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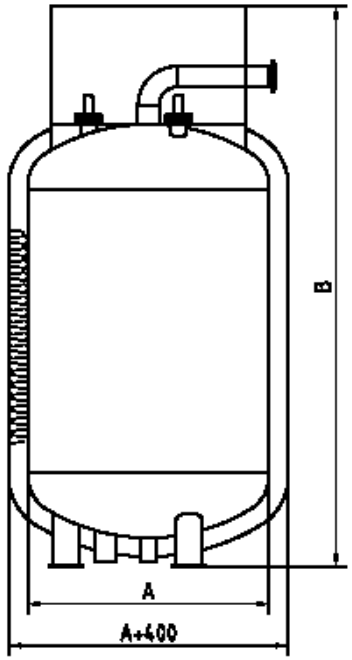
Electrode Steam Boiler Specifications

ZETA Electrode Steam Boiler Specifications

Model	Output (MW)			Dimension (mm)		Weight (tons)	
	6kV	10kV	15kV	(A) Diameter*	(B) Height**	Transport	Foundation
2000	2-10	2-15	-	2000	5600	6	18
2300	12	20	-	2300	5800	7	27
2600	15	25	28	2600	5800	9	32
2800	20	30	32	2800	6800	14	40
3200	25	40	50	3200	6800	18	50
3600	30	50	60	3600	7000	23	70
3800	35	60	70	3800	7000	28	80

*Add 400mm to diameter for insulation

**Height does not include NPSH for pump



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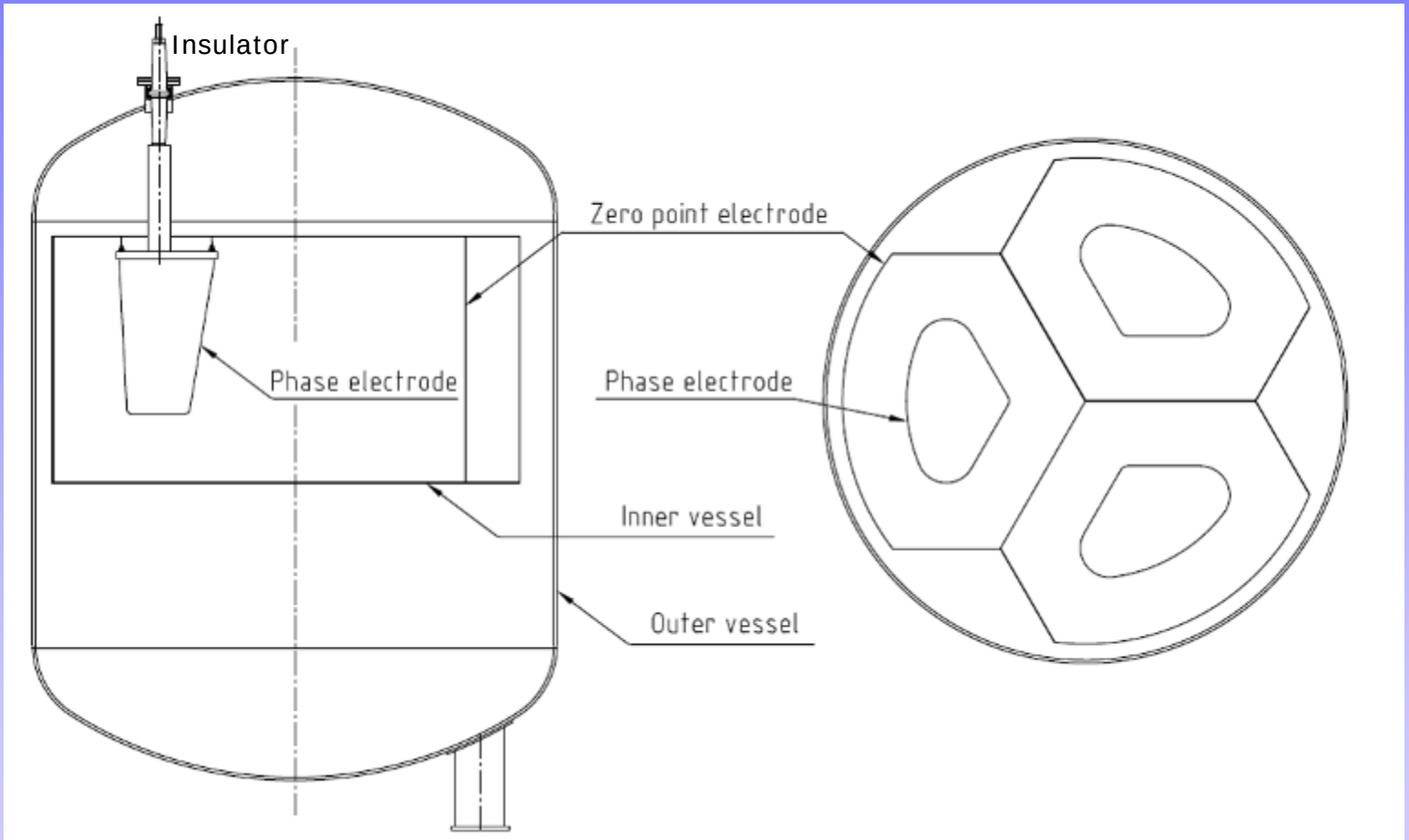
Steam Boiler: Main Parts



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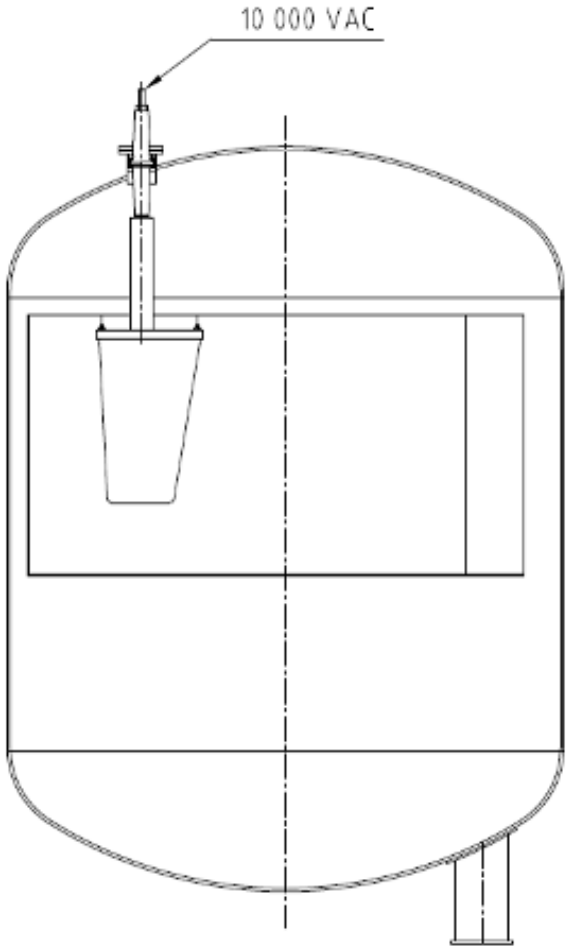
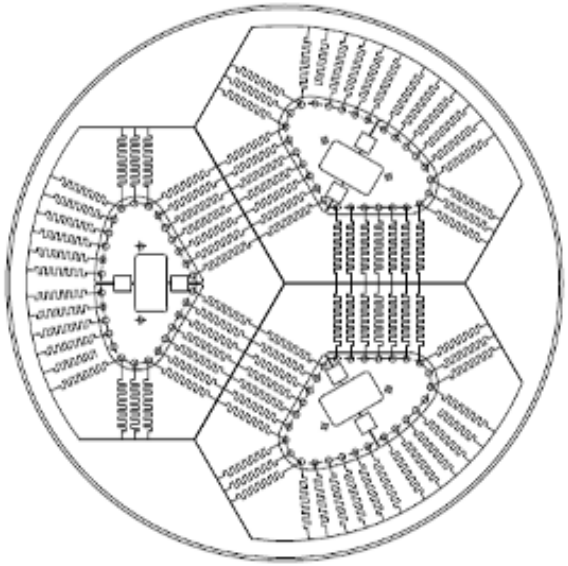
Electrical Flow in Inner-Vessel





Steam boiler is Y-conected.
Phase to phase 10 000 VAC
and phase to zero point 5 800 VAC

Steam is generated by passing electric current through the water

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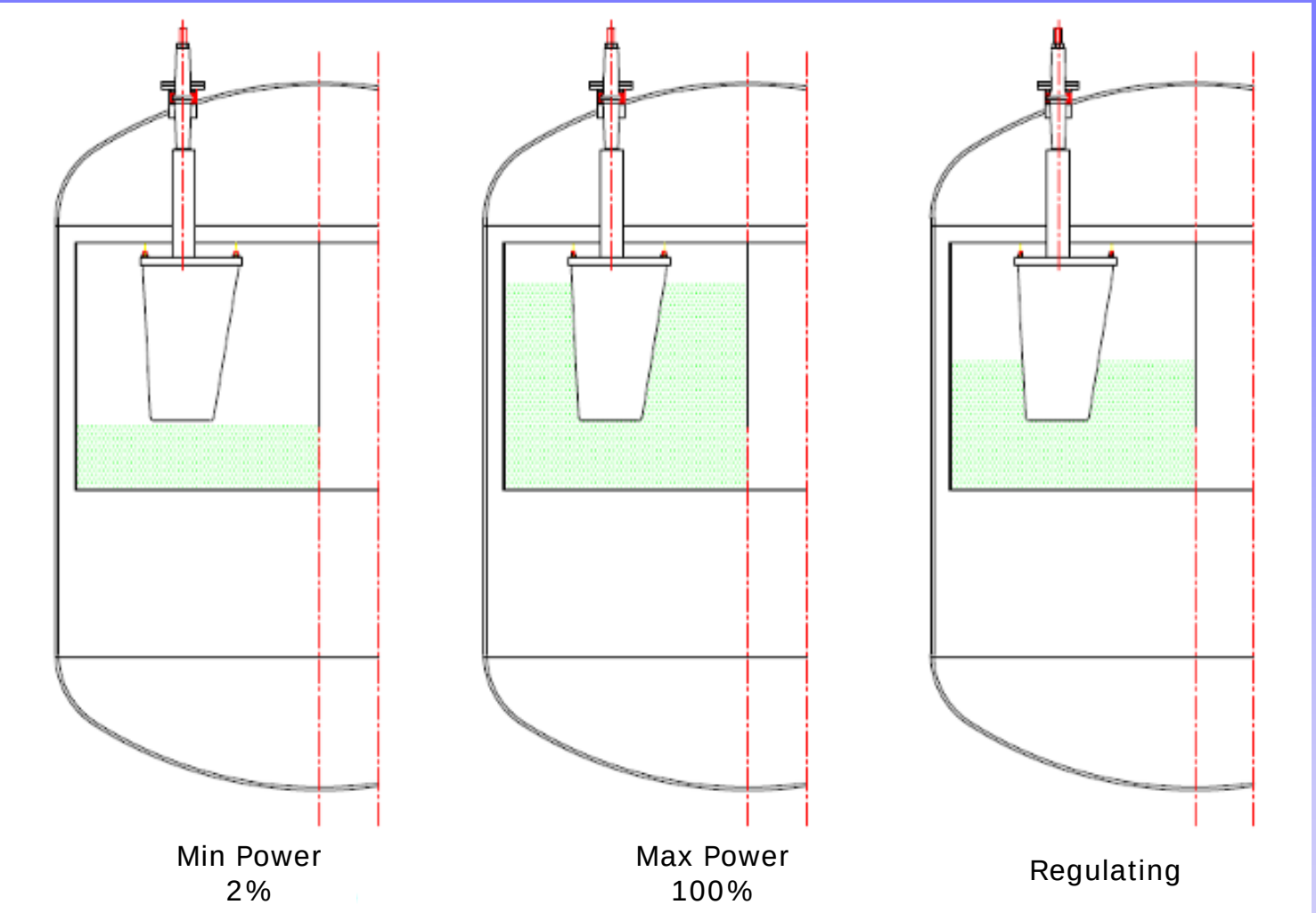
Power Output Modulation: Level Control



Steam is modulated via water level and maintaining constant water conductivity

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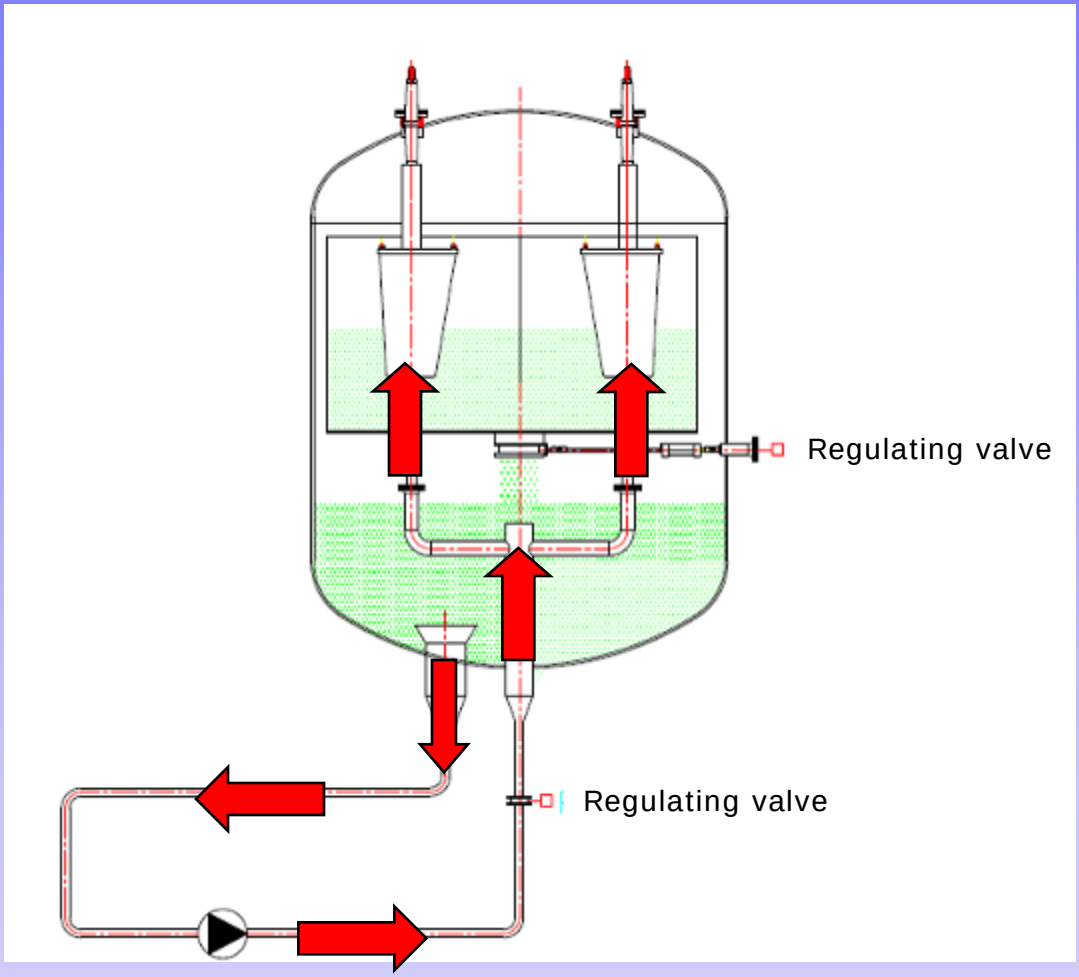
Steam Boiler: Water Level Control



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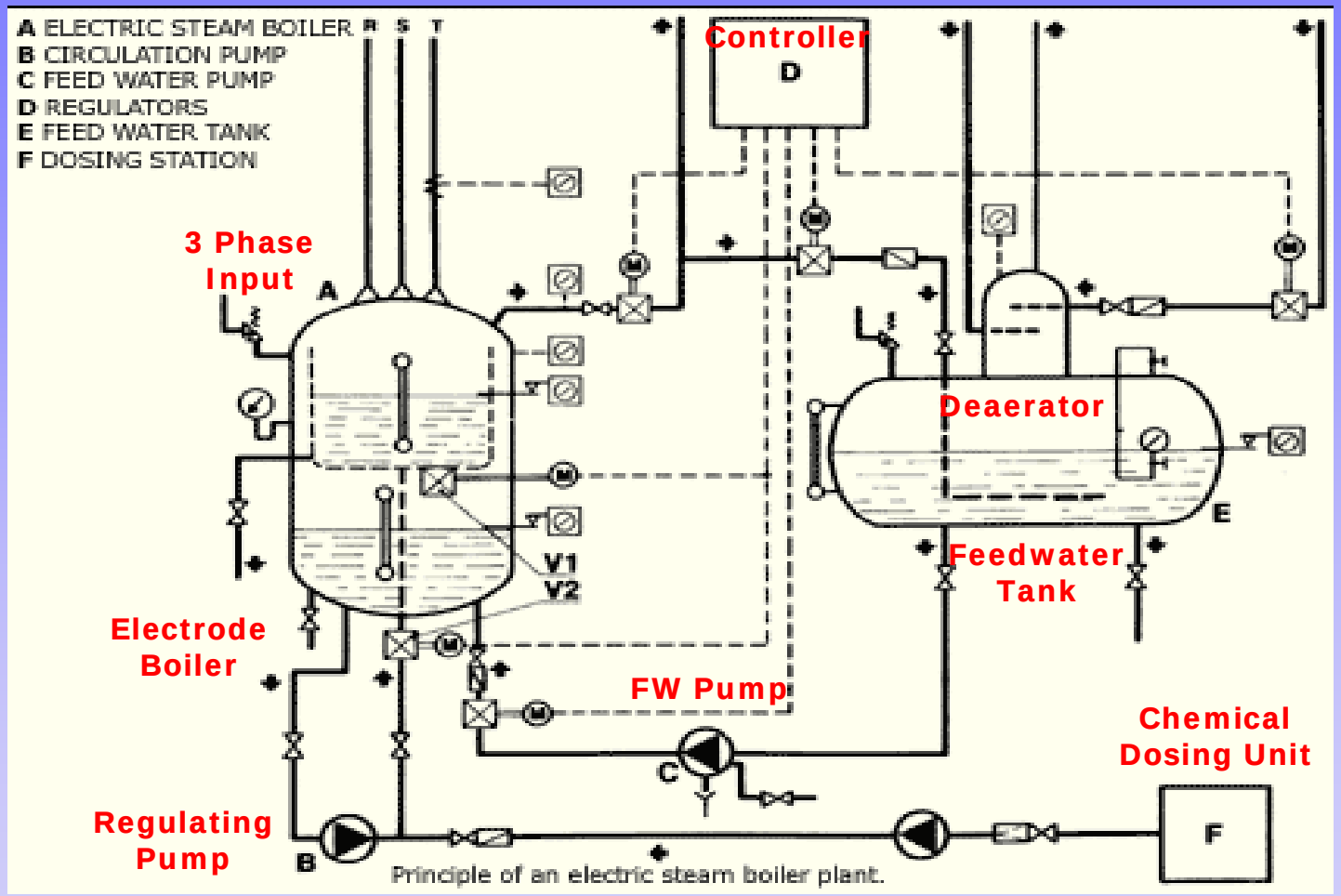
Basic Steam Boiler P&ID Diagram



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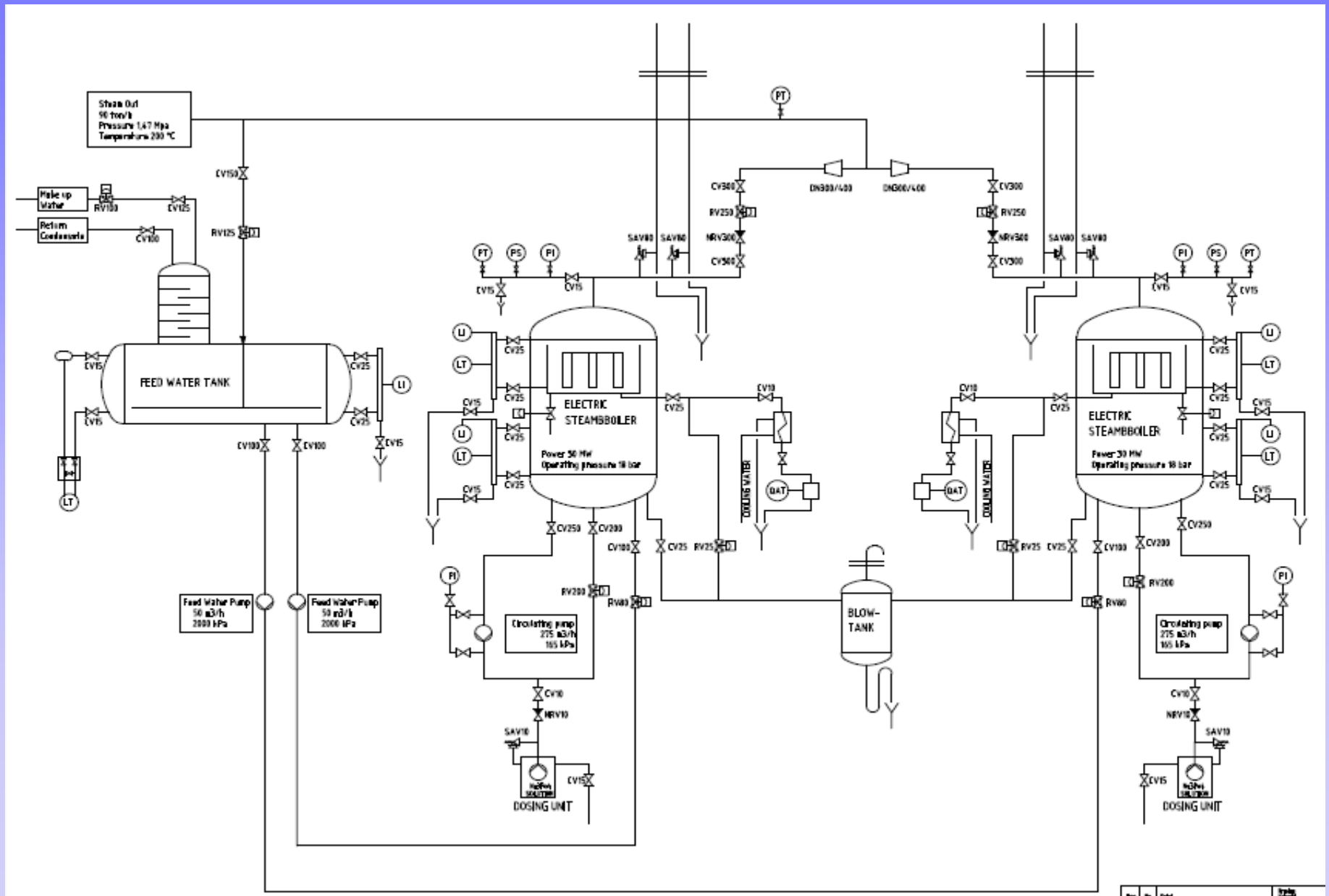
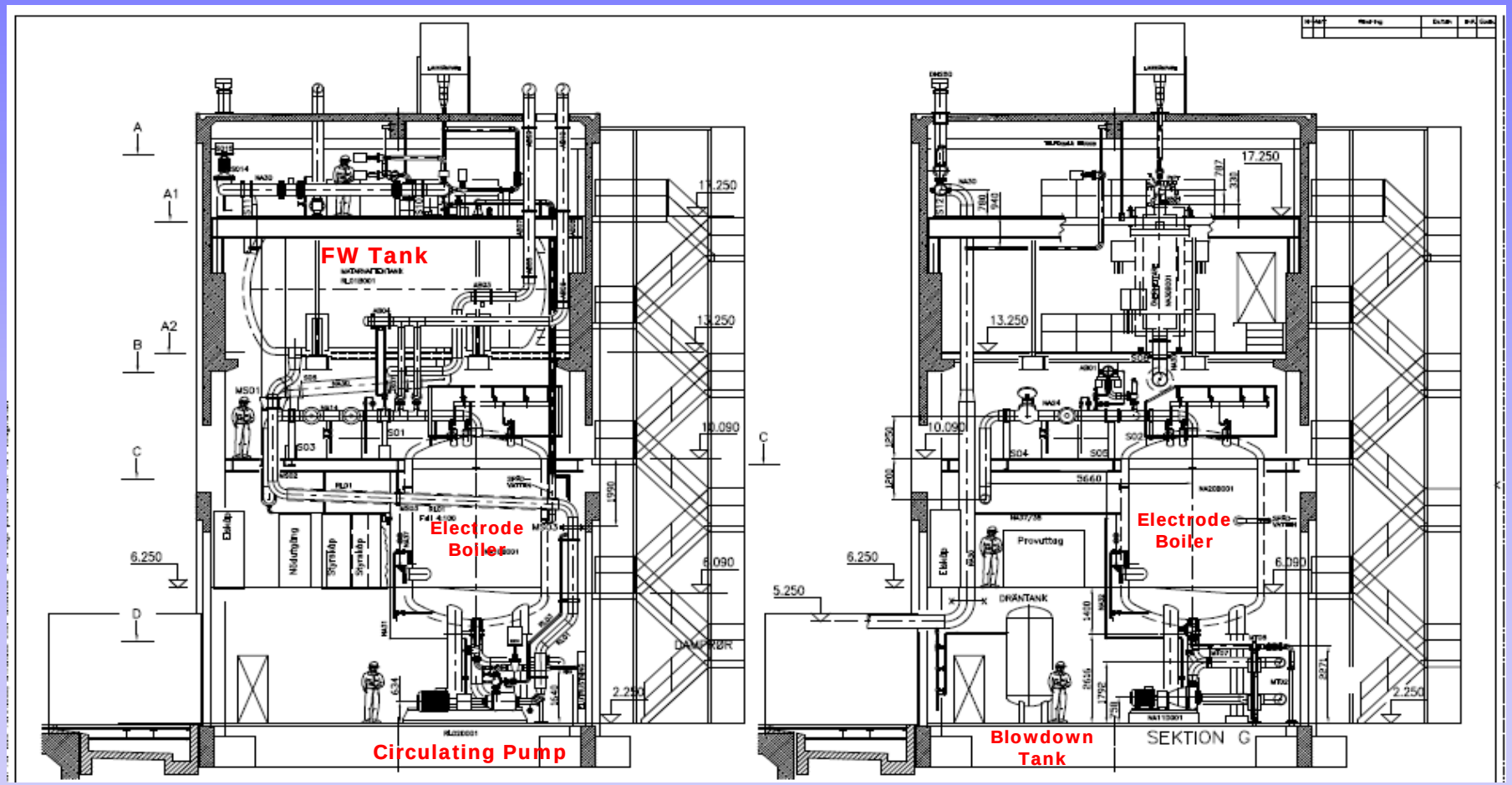
P&ID for Two Steam Boilers



Steam Boiler Layout: Side View



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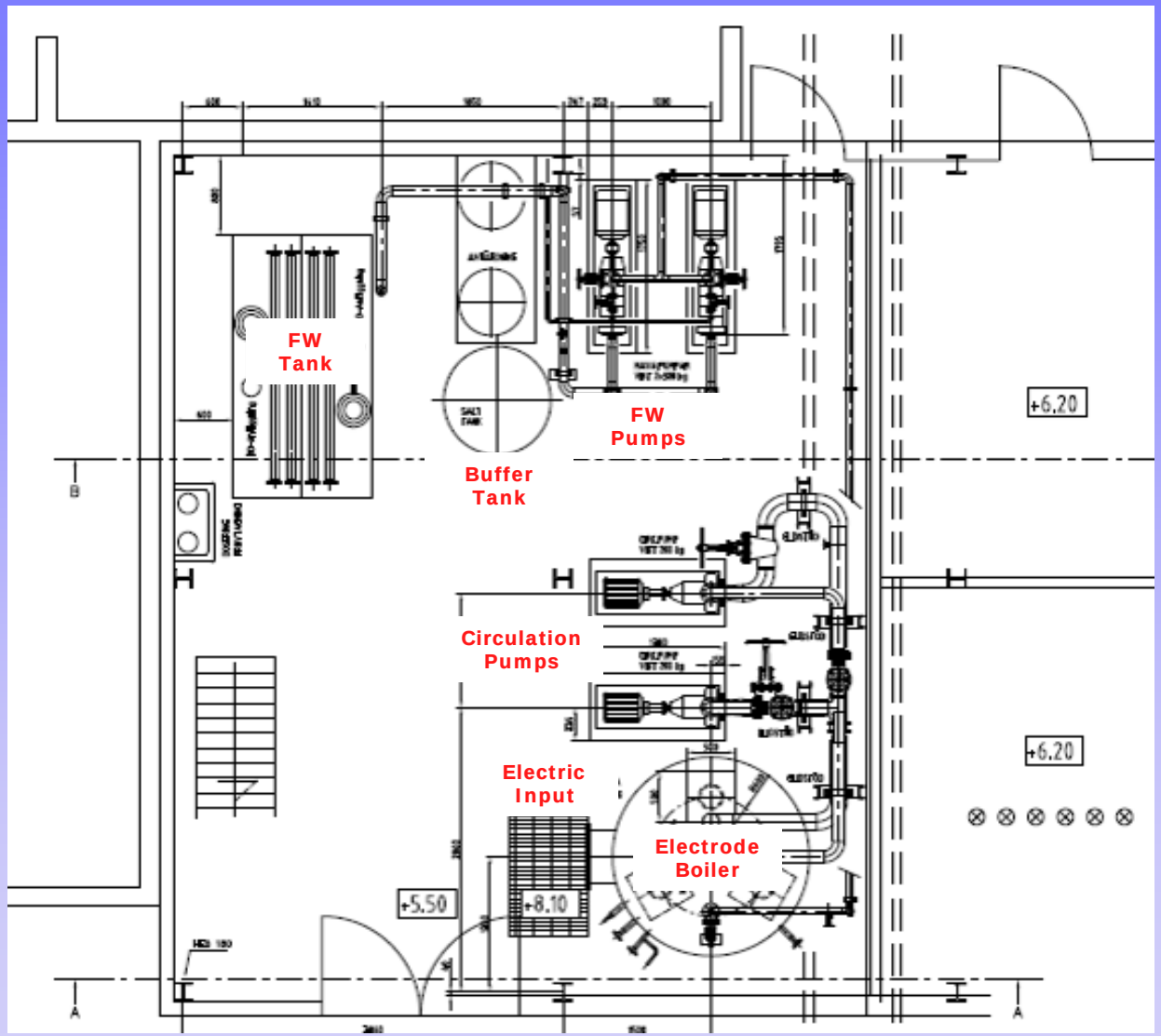
Steam Boiler Layout: Top View



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ZETA Electrode Steam Boiler in Sweden

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4MW Boiler with Service Platform

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Water treatment
(Typically supplied by NPP)

Softener and RO-plant

Buffer tank 5 000 liter

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8m³ Feed water tank

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Pumps in the plant

Chemical
Metering pump

Feed water pump

Circulation pump

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Water conductivity control

Conductivity meter

Sample coolers

Samples are taken from
-Steam boiler
-Feed water tank
-Steam pipe

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Control cabinet

Siemens PLC type S7-400

HMI Siemens Simatic touch screen

HMI gives you following informations:

- Overview picture of the boilerplant
- Operational modes
- Trend curves
- Alarm handling
- Historic values

Selection Criteria from NPPs on Electrode Auxiliary Boilers

1. Safety and Reliability
2. Good Steam Quality
3. Fast Start-up

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1. Safety and Reliability

100% Safety Record

- Over 80 years of service and no explosion accidents
- Other electrode boiler types (jet-type) have had explosions causing serious injuries*

Inherently safe design for steam explosions

- No water level means no steam generation
- Pump failure means no steam generation

Proven Reliability

- Boilers still in operation after 30 years
- Minimal moving parts for added reliability

*See Appendix A

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2. Steam Quality

Excellent Steam Quality:

- 99.9%+ Steam Quality
- <10ppb Na content

Excellent steam quality is achieved via:

- Low conductivity of boiler water (<100uS/cm)
- Large steam space with steam separator to prevent droplet formation during dynamic loads
- Large and calm steam generation surface

3. Fast Startup Time

- Cold Startup: ~2 hours to prevent stress
- Startup from standby to full power: 8-10 minutes
- Boiler kept on standby via immersion heaters
- Meets European Nuclear Power Plant Startup time requirements

Z&I ZETA Boilers Summary

- Zander & Ingestrom has over 80 years experience in Immersion Electrode Boiler design
- ZETA boiler has a perfect safety record throughout its history
- ZETA Boilers are used in more than 30 NPPs worldwide
- ZETA Boilers have high steam quality that meets requirements of Nuclear Power Plants
- Has the most number of electrode boiler units installed worldwide (over 1000)

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Hwa Seong Boiler with Z & I

- Hwa Seong Boiler to market the benefits of Electrode Boilers for Auxiliary Startup in Korean NPPs
- Authorize Hwa Seong Boiler as exclusive distributor of Z&I ZETA Electrode Boilers in Korea and all Korean-built NPPs overseas
- Z&I to provide engineering support, design drawings, core components for Hwa Seong
- Hwa Seong to build vessels and sell the complete boiler plant package to the customer

Appendices

Appendix A: Jet-type boiler Hydrogen Explosion Incident

Appendix B: Electrical Connection Requirements

Appendix C: Feedwater Requirements

Appendix A: Jet-type Electrode Boiler Explosion

- At 8:22am on August 11, 1995, the Sulzerjet-type electrode boiler at Switzerland's Leibstadt Nuclear Power Plant had an explosion
- Explosion injured two worker with second degree burns during maintenance and was caused by H_2 gas in the electrode boiler
- H_2 gas was generated via electrolysis:

  $2H_2O \rightarrow 2H_2 + O_2$
- H_2 gas generation was caused by high current through the water in jet-type boiler(1-2 A/cm)
- Subsequent measurement of jet-type boilers found H_2 concentration to be around 13ppm of H_2 gas
- Accident stopped all Jet-type boiler sales in Europe

Appendix A: ZETA Boiler's Safety Precaution to H_2 Explosion

ZETA boilers has a 100% safety record and have operated for over 80 years without any explosions

- ZETA Boilers have lower current through water of 0.15A/cm (1/10 of jet-boilers)
- ZETA boilers H_2 gas measurement is 1000 times less, at 1-3ppb versus 13ppm
- ZETA Boilers' design for safety also contributes to excellent steam quality

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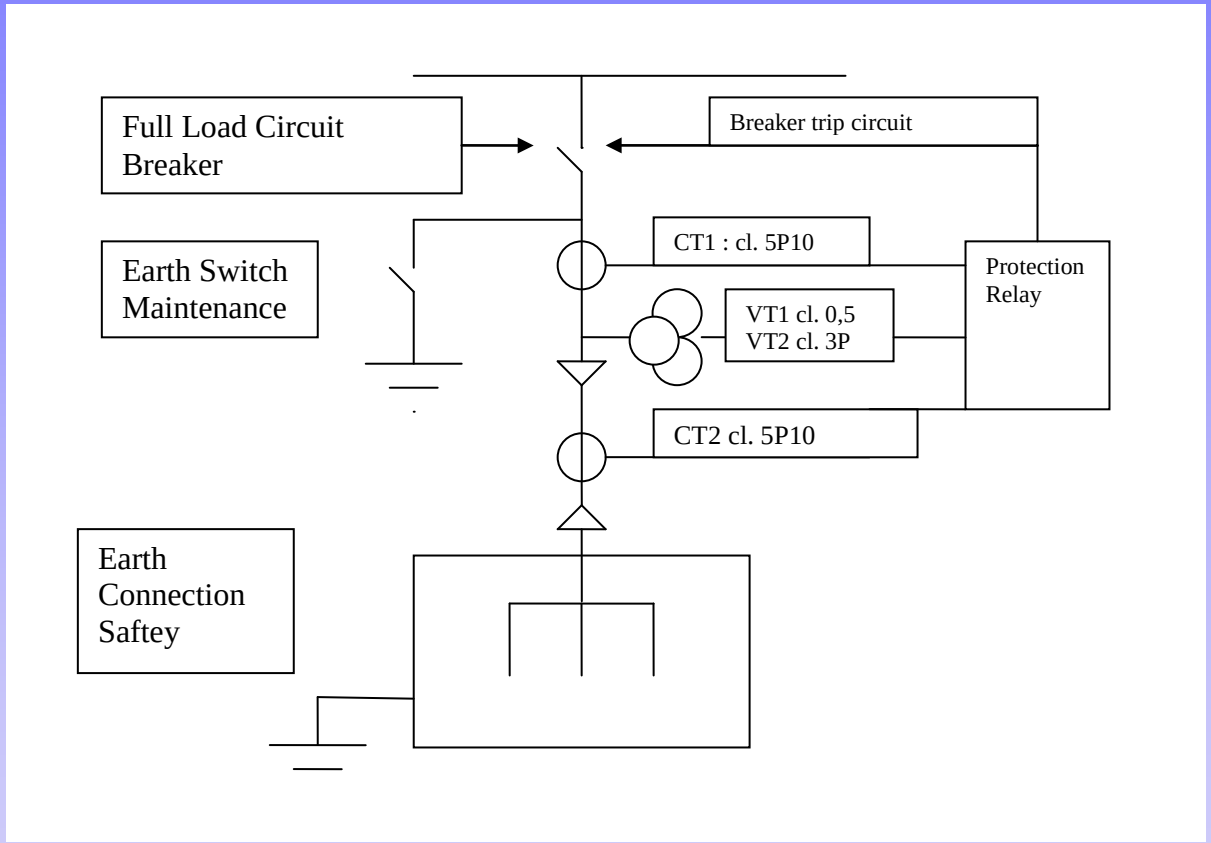
Appendix B: Boiler High Voltage Electrical Connection



Appendix B: Current and Voltage Transformer Design

- **CT 1**: 3 current transformers cl. 5P10
  - Current measurement for protection power actual value measurement for boiler load control
- **CT 2**: 1 cable current transformer cl. 5P10
  - Residual current measurement for earth fault and directional earth fault detection
- **VT1**: 3 voltage transformers cl. 0,5
  - Voltage measurement for protection and power actual value measurement for boiler load control
- **VT2**: 3 voltage transformers cl. 3P
  - Residual voltage measurement for earth fault and directional earth fault detection

100% Resistive Load

Appendix B: Protection Relay Trip Stages

ANSI	Stage	Function	Setting	Delay
50/51	I>	Over current	1,1 x In	20 s
50/51	I>>	Short circuit	2,0 x In	0,05 s
46	I2>	Unbalance stage	0,1 x In	20 s
32	P>	Overload	1,1 x Pn	10 s
59N	Uo>	Residual voltage	0,2 x Un	20 s
50N/51N	Io>	Residual current	0,02 x In	
49	T	Thermal overload	1,06 x In	60min
	THDu	Voltage THD	10%	60 s

Appendix C: Feedwater Requirements

Feedwater Requirements:

- Hardness: <0,01°dH
- Water Conductivity: < 5,0 µS/cm
- Oxygen : < 0,02 mg/l

Feedwater Equipment:

- Deaerator: Removal of oxygen
- Water Softener: Reduce water hardness
- Reverse Osmosis System: Lowers conductivity