SPX POWER+ENERGY

›Dry Cooling

Dry Cooling: A Solution for Water Consumption

June 2013

SPX POWER+ENERGY

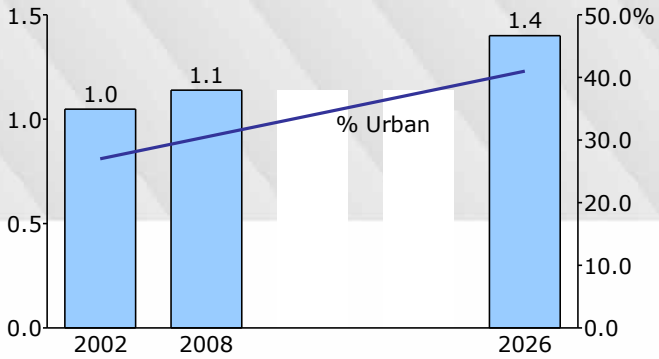
Executive Summary

- Water is a scarce commodity in India and will only become more scarce in the future
- SPX Cooling Technologies has the solutions for water related issues with Dry Cooling Technologies
- The latest technologies in Dry Cooling are available including flat single row and multi row tubes
- Dry cooling in many Indian provinces is an economically attractive alternative to other cooling methods

Dry Cooling can help India produce power economically while saving water

Water Scarcity: Rising Demand of Water

India Population (Billions) & Urbanization

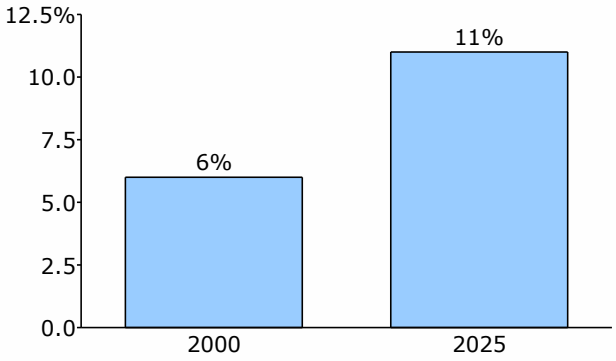


% Urban	27%		41%

Population growth means increased direct use of water as well as indirect use through increased need for agriculture and power

Most of the population growth will be in urban areas which will intensify water needs in those areas

India Industrialization (% of total Water Consumption)



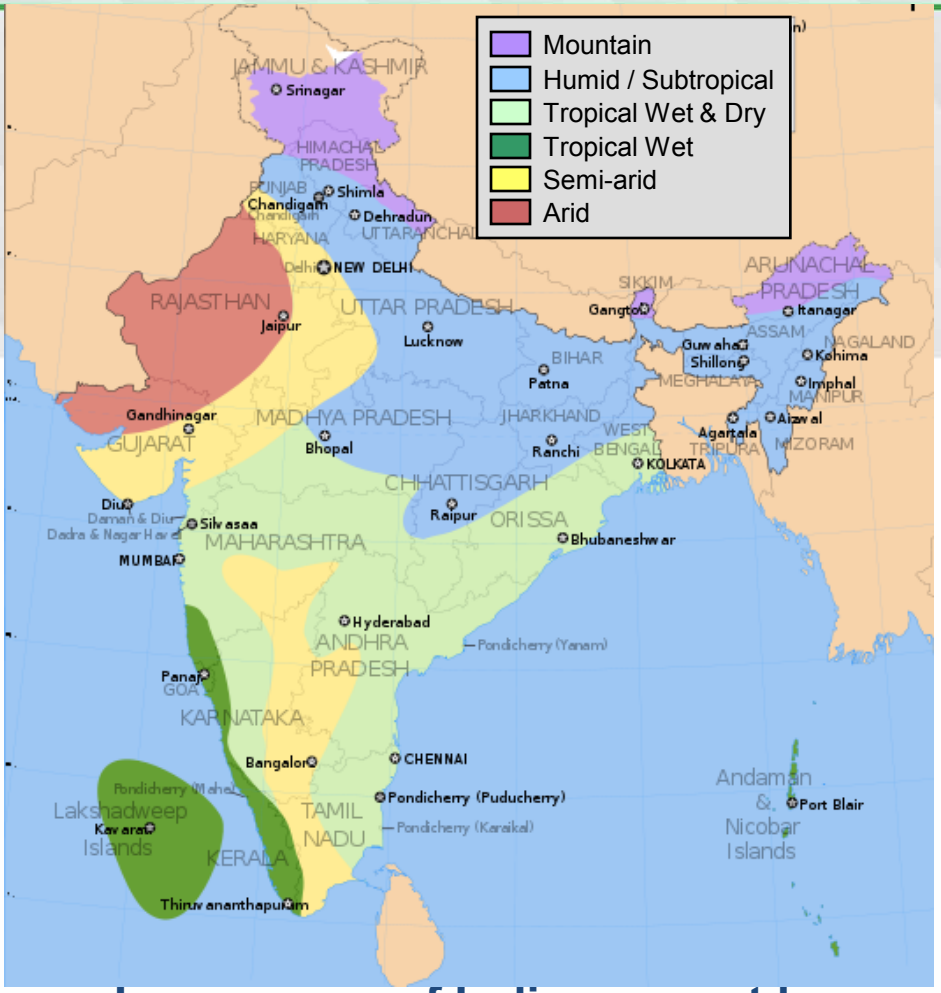
Industrialization will continue in India
Industrial companies use water for multiple processes

Sources: National Population Stablization Fund , Population Foundation of India , Grail Research from NY Times

Concentrated Population and Industrialization growth will require more water

Water Availability: Increasing Water Stress

Water availability is localized

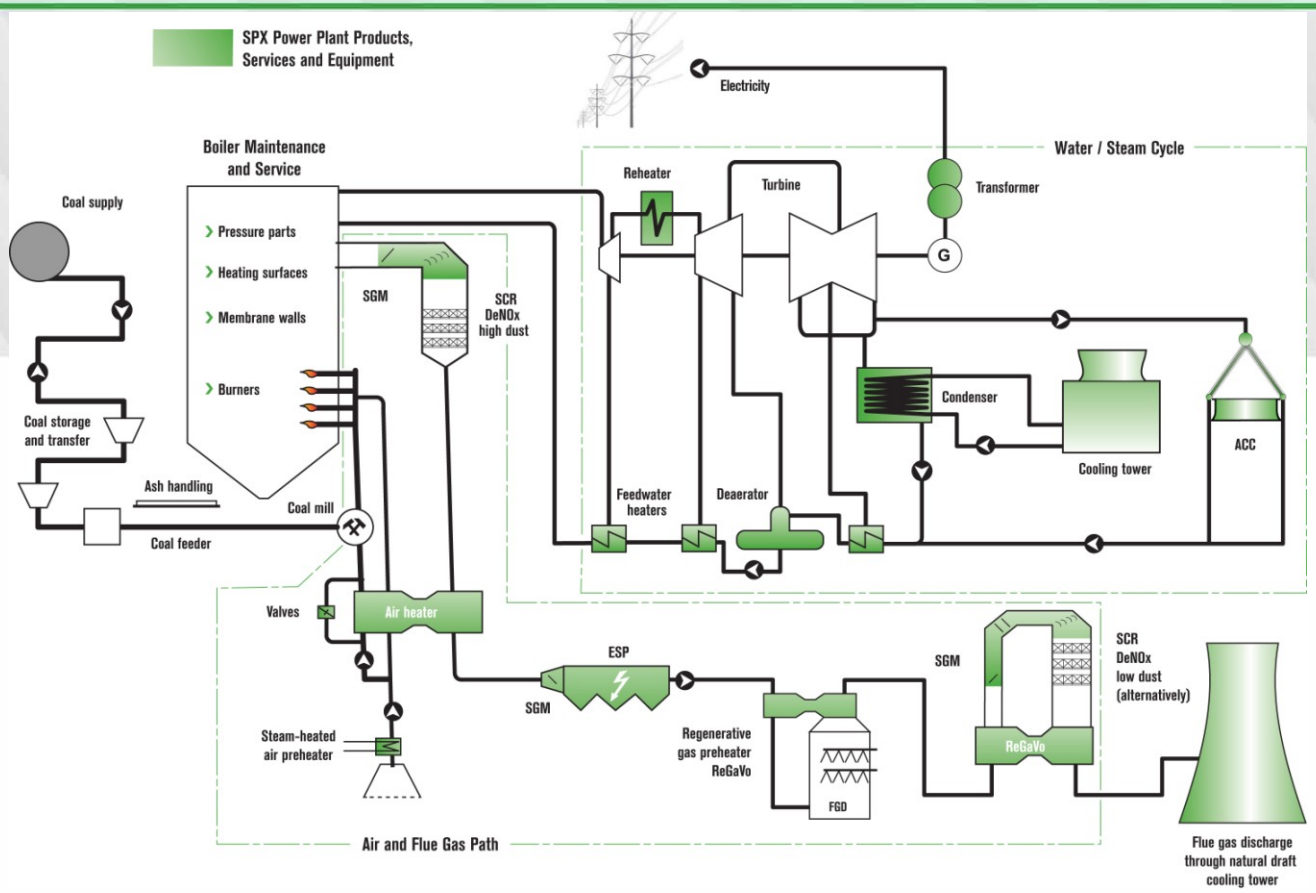


- Semi-arid and arid zones have clear lack of water availability
- Tropical Wet & Dry areas rely on Monsoons which vary annually
- Humid / Subtropical areas also have greatest demand with priority on public consumption
- World Business Council added India and South Africa to areas of high water stress for 2025 (water withdrawn exceeds water available)

Sources: World Business Council, Wikipedia, India Meteorological Dep.

Large areas of India may not have a sustainable source of water for power

SPX Overview



SPX Facts

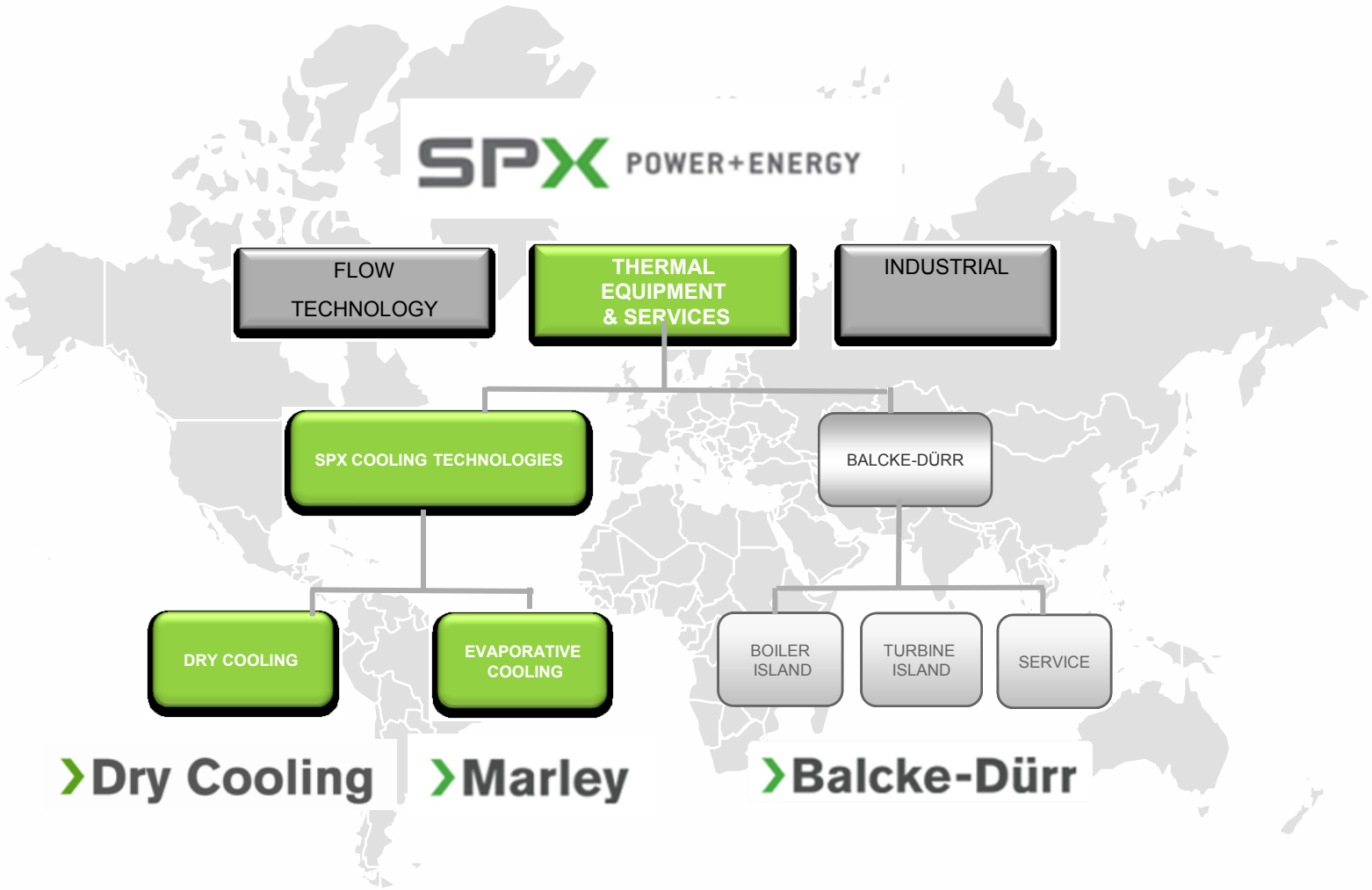
Headquarter : Charlotte US
SPX Revenue :$6Bn
(INR 33000 Cr)

- Employees:17000+ globally

- Thermal Equipment and Services Centers of Excellence:
- Ratingen, Germany
- Brussels, Belgium
- Bridgewater, NJ USA
- Overland Park, KS USA

SPX is a diverse global company focused on Power Generation

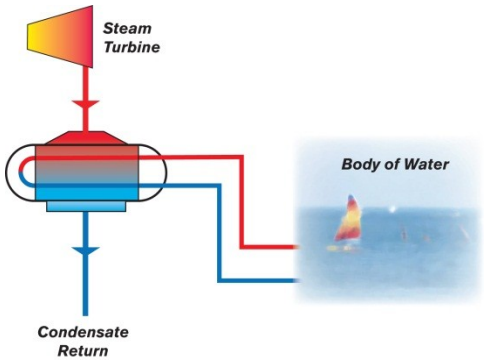
SPX Power & Energy - Overview



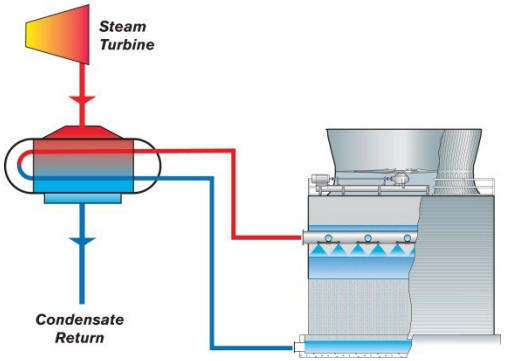
SPX is a diverse global company with a broad product portfolio focused on Power & Energy

Principle Concepts for Cooling

Evaporative Cooling

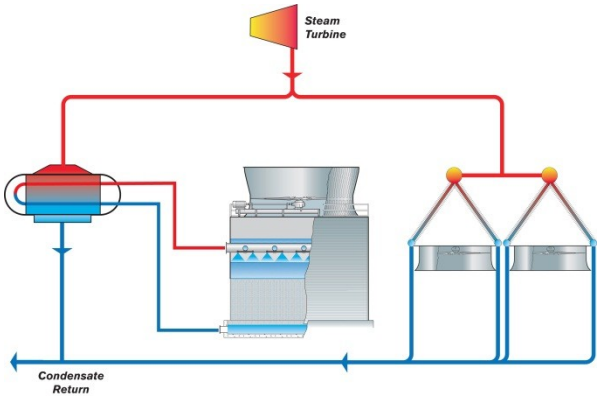


Once Through Cooling

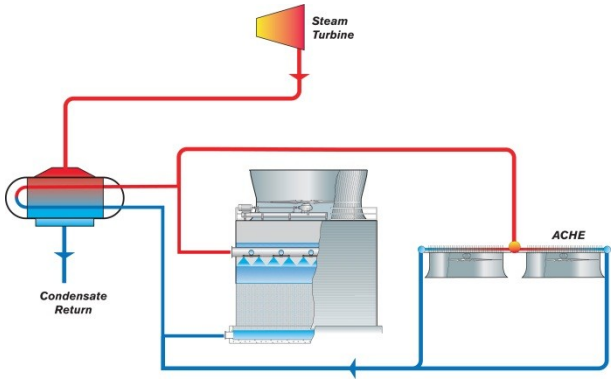


Evaporative / Hybrid Cooling Tower

Parallel Systems

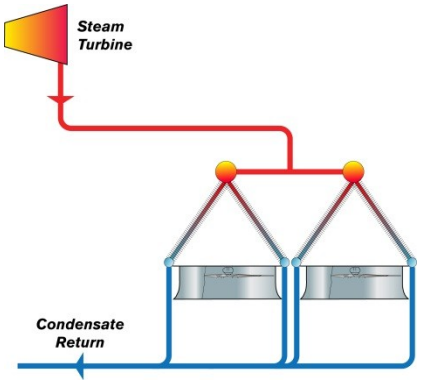


Parallel Condensing System

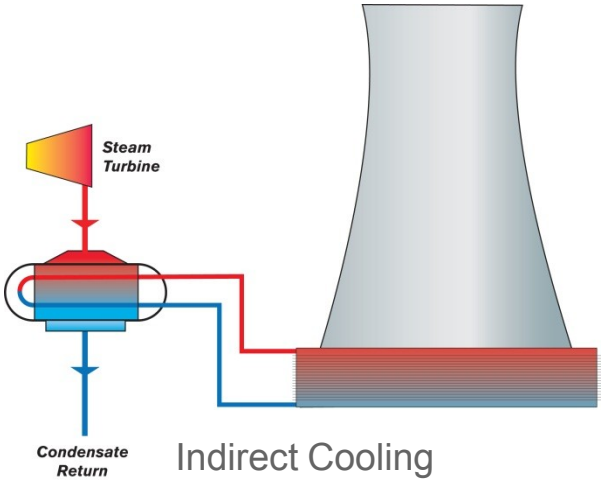


Parallel Cooling System

Dry Cooling



Air Cooled Condenser (ACC)



Indirect Cooling

Dry Cooling can help produce power economically while saving water

Cooling Concept Comparisons

	Once Through	Evaporative Cooling Tower	Parallel Systems	Indirect Dry Cooling Tower	Air Cooled Condenser
Water Use*	750 GPM	750 GPM	Varies	0 GPM	0 GPM
Power Use*	13.5 kW/MW	19 kW/MW	19 kW/MW	10 kW/MW	19 kW/MW
Advantages	▪ Cost Effective with small footprint ▪ Low back pressure operation ▪ No noise pollution	▪ Low continuous use of water ▪ Low back pressure operation	▪ Equipment sized for water availability ▪ Smaller footprint than full dry	▪ Can be located at fuel source ▪ Low auxiliary power usage ▪ Less time for permits	▪ Can be located at fuel source ▪ No Water Usage ▪ Less time for permits
Disadvantages	▪ Plant site to be near water ▪ Conflict for water availability ▪ Environmental concerns	▪ Reliable water source required ▪ Water treatment required ▪ Plume formation ▪ Maintenance costs	▪ More complicated operation ▪ Higher upfront cost and footprint than full wet	▪ Largest footprint ▪ Lowest cycle efficiency ▪ Cooling driven by dry-bulb temperature	▪ Highest installed cost ▪ Lowest cycle efficiency ▪ Cooling driven by dry-bulb temperature

* Note: values are estimates of the entire system and may change with system design and conditions

Dry Cooling is the best option when water is not a long term option

Dry Cooling: Air Cooled Condenser

Background

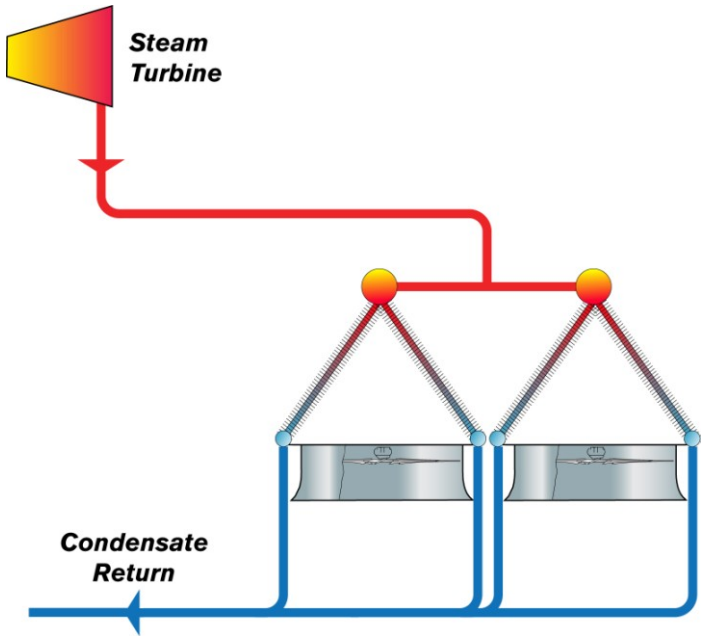
- Air passes through fan and over coils to both reject heat and condense steam
- Over 90% of Dry Systems are ACC's

Advantages

- Can be located at fuel source
- No water required
- No plume formation
- No impact on environment
- Less permits & time for permitting required

Disadvantages

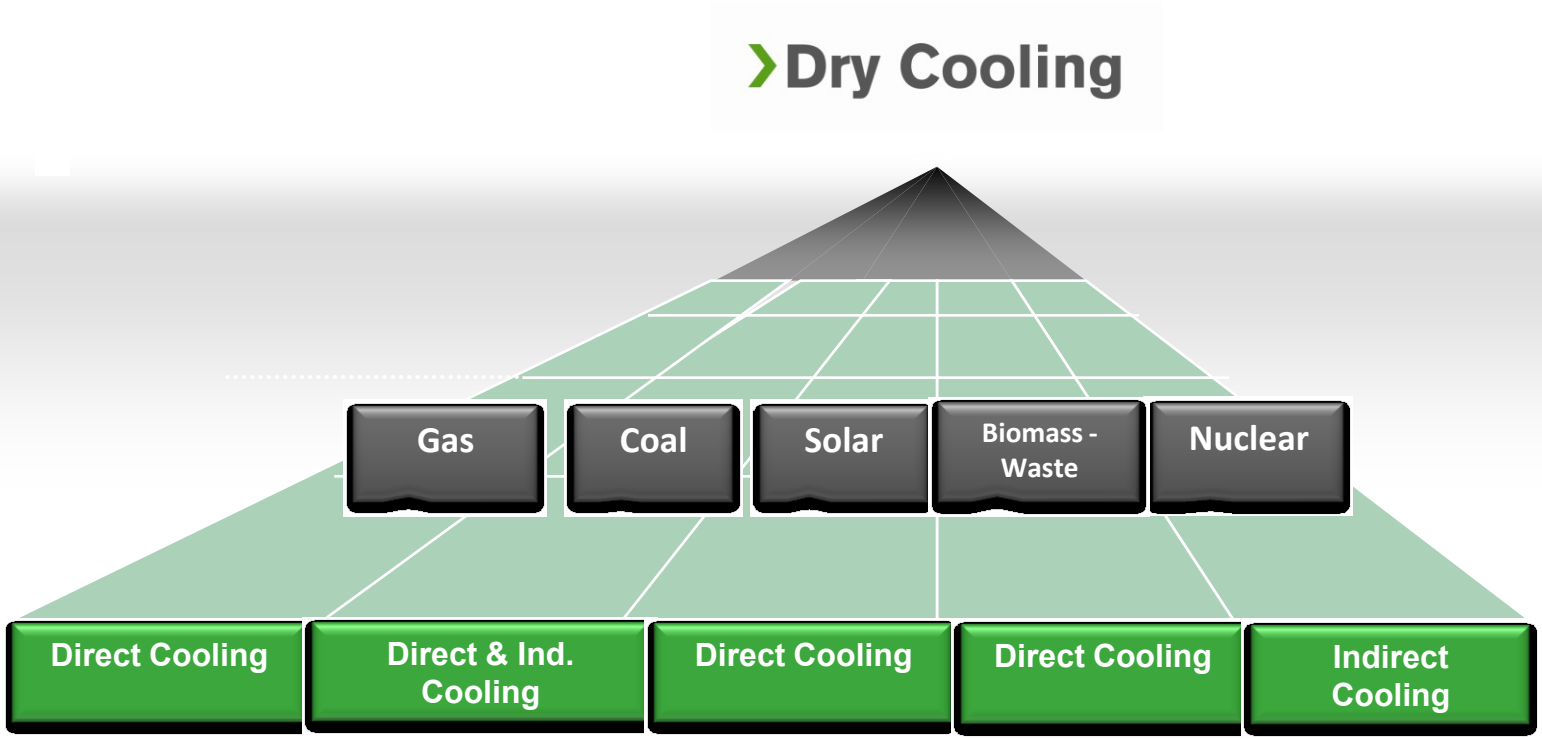
- Higher installed cost
- Larger footprint
- High parasitic power usage
- Lower cycle efficiency
  - Cooling driven by dry-bulb temperature



Common as water scarcity, cost, and risk increase

SPX Power Plant Offerings

SPX POWER+ENERGY

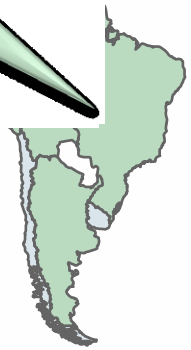


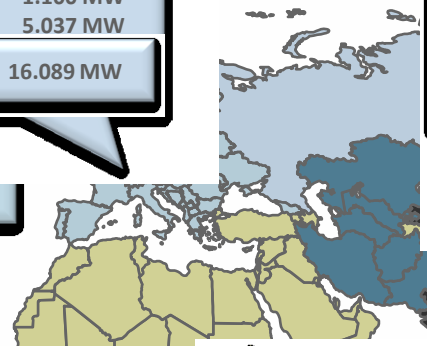
SPX is a Leading Global Supplier of Engineered Products and Solutions that are Critical to the Thermal Performance and Safety of Many Types of Power Plants

Dry Cooling MW Power Plants Worldwide

Dry Cooling

Status 2013 YTD - April
Only projects > 100 MW





BELGIUM	1.150 MW
GREECE	550 MW
IRELAND	790 MW
ITALY	6.532 MW
LUXEMBURG	360 MW
NETHERLANDS	570 MW
SPAIN	1.100 MW
UK	5.037 MW
EUROPE	16.089 MW

14%

GANSU	2.800 MW
HEBEI	1.860 MW
HENAN	690 MW
INNER MONGOLIA	15.960 MW
JILIN	2.400 MW
NINGXIA	2.400 MW
SHANXI	19.105 MW
SHAANXI	3.920 MW
XINIANG	4.720 MW
CHINA	53.855 MW

46%

CANADA	1.470 MW
MEXICO	4.240 MW
USA	16.489 MW
ARGENTINA	240 MW
PERU	1.630 MW
VENEZUELA	1.000 MW
AMERICAS	25.069 MW

21%

ALGERIA	150 MW
BARHAIN	800 MW
JORDAN	1.217 MW
MOROCCO	470 MW
SOUTH AFRICA	8.880 MW
SYRIA	660 MW
TURKEY	760 MW
SAUDI ARABIA	1.700 MW
AFRICA & MIDDLE EAST	15.157 MW

14%

BANGLADESH	200 MW
INDIA	120 MW
INDONESIA	420 MW
IRAN	600 MW
JAPAN	330 MW
KOREA	105 MW
MALAYSIA	300 MW
PAKISTAN	130 MW
TAIWAN	2 .580 MW
VIETNAM	250 MW
APAC	5.035 MW
AUSTRALIA	705 MW

4%

Dry Cooling Solutions in Gas
Direct Cooling - Air Cooled Condenser

Product Description

Directly condense the turbine exhaust steam from the steam turbine and return condensate to the boiler without water loss.

They are frequently used in electrical power plants of all sizes

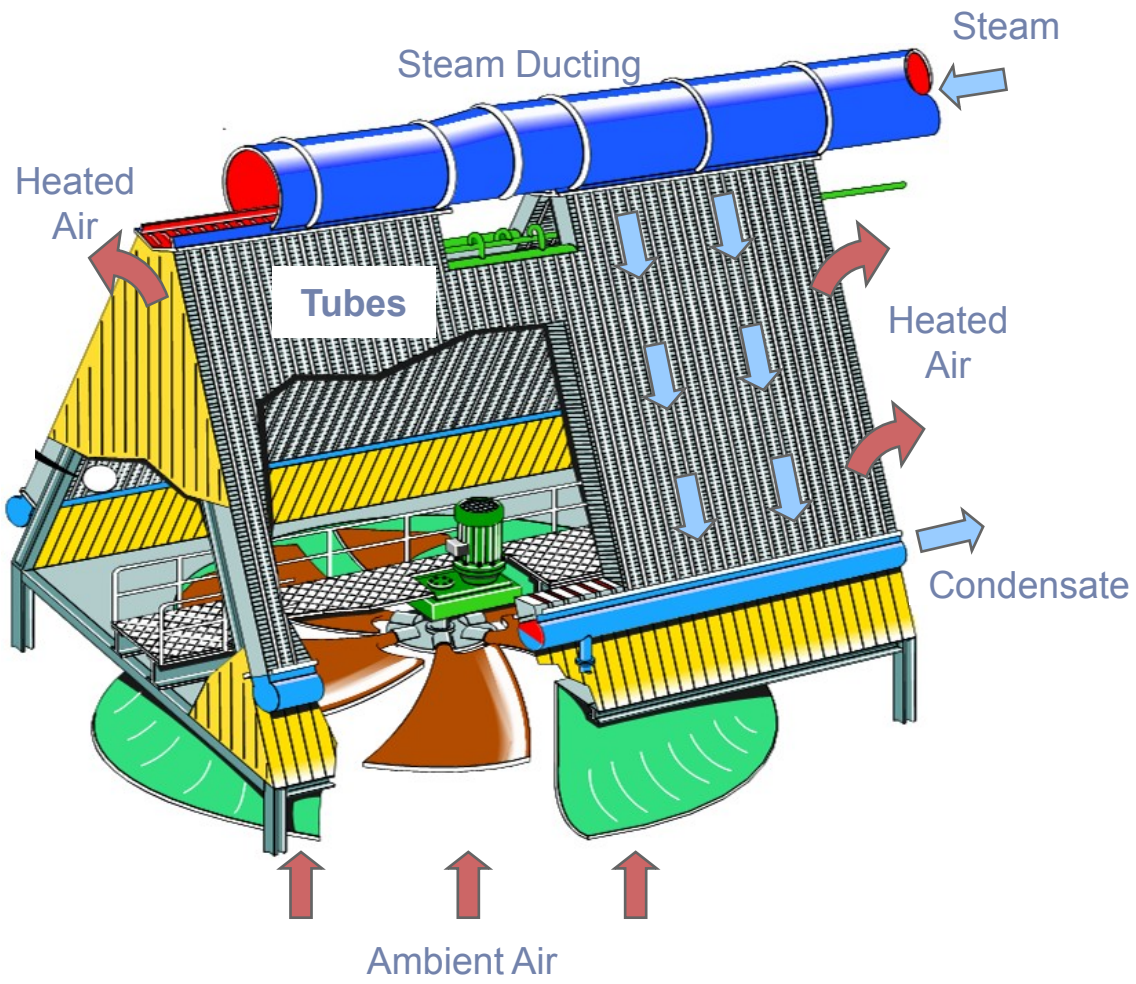
Features

Air Cooled Condenser is a direct dry cooling system where the steam is condensed inside air-cooled finned tubes. Since there is no intermediate surface condenser like Indirect dry cooling, the overall performances is better

Dry Cooling Solutions in Gas
Air Cooled Condenser

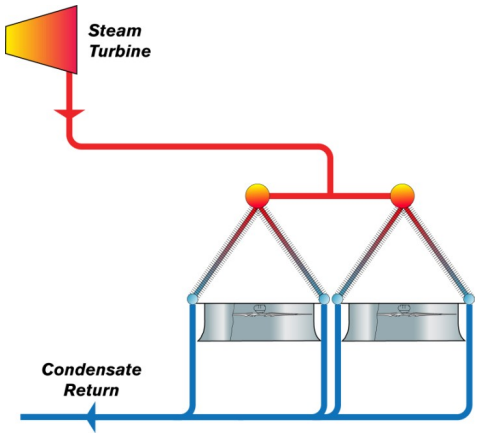
Challenges	• High operating flexibility • Operating cost • Diverse and challenging climates, from hot to freezing conditions • Strict environmental imposition including low noise
Existing SPX Solutions	Dry Cooling Systems with SPX SRC™ finned tube technology: • Forced Draft • Induced Draft (Hexacool®)
What makes the product special	• Elimination of additional water usage from the condensing power cycle • Excellent corrosion and freeze resistance • Long-term mechanical and thermal integrity • Low fan power consumption • Flexibility in power plant site selection • Decreased time required for plant permitting
Current Activities	• More than 100 units in commercial operations • More under design, construction and commissioning

Direct Dry Cooling Technology
A-Frame : Operational Detail



Basics of Operation

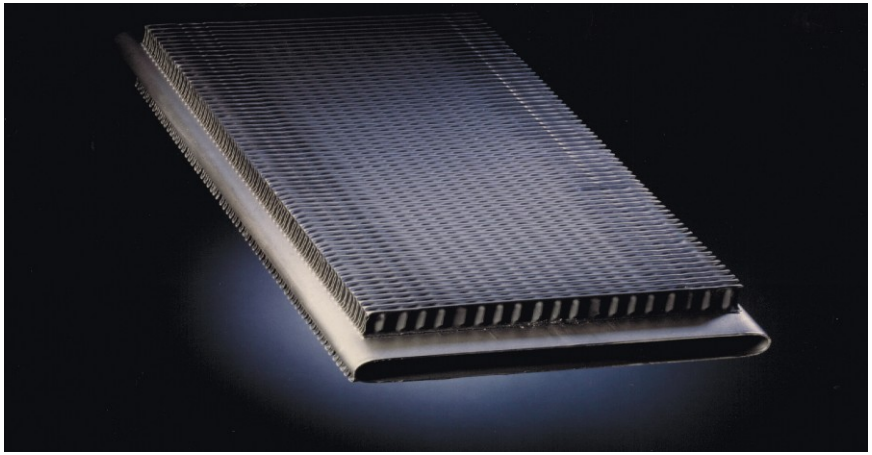
- Air travels up through fan and passes over tubes
- Steam arrives through ducting and condenses in tubes as heat is transferred to air
- Condensate at bottom of tubes returns to system



Heat transfer tubes are critical to ACC performance

Direct Dry Cooling Technology (ACC)

Flat Shape Tube



Carbon steel / Aluminium

General Design Features

Core Tube
- flat shape
- steel tube
- Aluminium coated

High steam side flow area
- brazed fins
- aluminium fin

Single Row System
- suppression of steam side maldistribution
- flexibility to operation requirements (flow area; pressure drop)

Proven Technology

Gas application - Combined Cycle Power Plants

Combined Cycle projects

Turano - 800 MW
Italy

Langage – 850 MW
United Kingdom

Alba – 2x800 MW
Bahrein

Riyadh PP11 – 2x850 MW
Saudi Arabia

Goreway – 800 MW
Canada

Rio Bravo – 3X515 MW
Mexico

SPX is a full-line, multi-service manufacturer of

- Air-cooled condensers

Products and solutions are marketed to

- Gas
- Solar
- Coal
- Renewables - Biomass

Gas Combined Cycle Power Plant Reference List

Project Name	Type of plant	Country	Plant MW	Year
Samra III	Combined Cycle Power Plant	Jordan	140	2014
San Luis de la Paz	Combined Cycle Power Plant	Mexico	205	2014
Dominion - Front Royal - Warren County	Combined Cycle Power Plant	USA	1329	2013
Denizli	Combined Cycle Power Plant	Turkey	200	2012
Chilca Uno	Combined Cycle Power Plant	Peru	810	2011
Deer Creek	Combined Cycle Power Plant	USA	300	2011
Kallpa	Combined Cycle Power Plant	Peru	832	2011
Riyadh	Combined Cycle Power Plant	Saudi Arabia	1700	2011
Tracy GWF	Combined Cycle Power Plant	USA	315	2011
Al Qatrana	Combined Cycle Power Plant	Jordan	400	2010
Bachaquero	Combined Cycle Power Plant	Venezuela	500	2010
Torino North	Combined Cycle Power Plant	Italy	400	2010
Colusa (CA)	Combined Cycle Power Plant	USA	660	2009
Halton Hills (Ontario)	Combined Cycle Power Plant	Canada	670	2009
Turano Lodigiano	Combined Cycle Power Plant	Italy	800	2009
Amman East Power	Combined Cycle Power Plant	Jordan	400	2008

** Selected projects amongst hundreds of references*

›Dry Cooling

Case Study - Gas - Combined Cycle
Turano Lodigiano (ACC) Italy

Location – Bertonico-Turano Lodigiano in Northern Italy, a 800 MW Combined Cycle Power Plant

Challenge - Allow maximum operating flexibility in accordance with legal atmospheric pollutant emission criteria. Focus on the real needs, proactive collaboration, technical expertise and careful planning and monitoring of work

SPX Solution – Focus on environmental and architectural issues and an excellent operating flexibility

Customer Benefit – High performance, low back pressure even during Winter conditions. Overall net efficiency of the plant > 57% - Customer's official satisfaction letter

›Dry Cooling

Case Study – Gas - Combined Cycle Langage (ACC), United Kingdom

Location – Langage,Plymouth, United Kingdom. A 850 MW Combined Cycle Power Plant

Challenge –Ability to provide grid stabilization and spinning reserve services when integrated on the grid with wind energy

SPX Solution – quick response and low load “parking” at night while remaining below air emissions limits.

Customer Benefit – With an extraordinary architectural design that blends into the natural surroundings, Langage is now a local landmark

› Dry Cooling

Dry Cooling Solutions in Solar Air Cooled Condenser

Challenges	• High operating flexibility • Minimize operating and maintenance cost • Hot, arid and dusty environment with large solar irradiation
Existing SPX Solutions	Dry Cooling Systems with SPX SRC™ finned tube technology: • Forced Draft • Induced Draft (Hexacool®)
What makes the product special	• Elimination of additional water usage from the condensing power cycle • Long-term mechanical and thermal integrity • Low fan power consumption • Special solution dedicated to solar tower systems
Current Activities	• 5 units in commercial operations • More under design, construction and commissioning

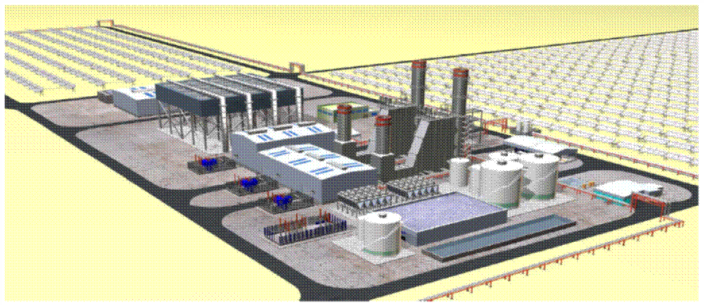
› Dry Cooling

Solar application – Concentrated Solar Power Plants

Example of Solar Projects

Hassi R'Mell – 150 MW
Algeria

Ain Beni Mathar – 470 MW
Moroco



Reason for using Dry Cooling

- No water available at site
- Environmental regulations for water saving
- Environmental regulations, limiting the temperature increase in rivers and seaside
- Renewable sources

Solar Power Plants
Reference List

Project Name	Type of plant	Country	Plant MW	Year
Ain Beni Mathar	Solar Power Plant	Morocco	470	2009
Hassi R'Mell	Solar Power Plant	Algeria	150	2009
Genesis	Solar Power Plant	USA	250	2012
Upington	Solar Power Plant	South Africa	50 MW	2012
Paulputs	Solar Power Plant	South Africa	100 MW	2012

Dry Cooling

Case Study – Solar
Hassi R'Mell (ACC), Algeria

- **Location –** Region of Hassi R'Mel in the province of Laghouat, Algeria, a 150 MW integrated solar Combined Cycle Power Station
- **Challenge –** Allow optimized power plant output in a high ambient temperature arid environment by optimizing the condensing capacity
- **SPX Solution –** Focus on an optimized solution with maximum flexibility for best turbine back pressure control in winter and summer conditions
- **Customer Benefits –** High performance dry cooling condenser without need of water in an arid area and integrated in an environment-friendly power plant with low carbon emissions

› Dry Cooling

Dry Cooling Solutions in Coal
Direct Dry Cooling – Air Cooled Condenser

Product Description:

Air cooled condenser for coal fired power plants, behind steam turbine building with typical arrangement of 2x150 MW up to 2x1000 MW

Features :

- High efficiency SRC ™ finned tubes
- Free-expansion tube bundles
- A-framed supported tube bundles
- Steel structure or round concrete columns support
- Low noise design for near & far field
- Low hot air recirculation design
- High wind design

Dry Cooling Solutions in Coal
Direct Dry Cooling – Air Cooled Condenser

Challenges	• Large capacity steam condensing for maximum electrical output • Coal mine areas with dusty and corrosive environment • Diverse and challenging climates, from hot to freezing conditions with risks of mechanical wear • Base load operation requiring high availability
Existing SPX Solutions	SPX SRC ™ Air Cooled Condenser – Direct Condensing
What makes the product special	• High efficiency thermal cycle with low back pressure and low power consumption for maximum heat rate • High performance finned tubes with excellent cleaning ability for long term availability • A-Frame supported tube bundles, allowing heat exchanger free thermal expansion for maximum reliability
Current Activities	• More than 150 units in commercial operations • Many more under design, construction and commissioning

›Dry Cooling

Coal Fired Power Plants - ACC

Example of Projects

Zhenglan – 2x600 MW
China

Wuxiang – 2x600 MW
China

Longshan – 2x600 MW
China

Wygen – 100 MW
USA

Kusile – 6x800 MW
South Africa

Product Description:

Air cooled condenser for coal fired power plants, behind steam turbine building with typical arrangement of 2x120 MW up to 2x1.000 MW

Features :

- High efficiency SRC ™ finned tubes
- Free-expansion tube bundles
- A-framed supported tube bundles
- Steel structure or round concrete columns support
- Low noise design for near & far field
- Low hot air recirculation design
- High wind design

Performance Curve for ACC

Client	CEA	Document Reference	09-101-0162-032_a3_PCUB0001
Location	Jhajjar (India)		
Document	**PERFORMANCE CURVES FOR CONSTANT DRYNESS**	Proposal Nr	09-101-0162-032_a3

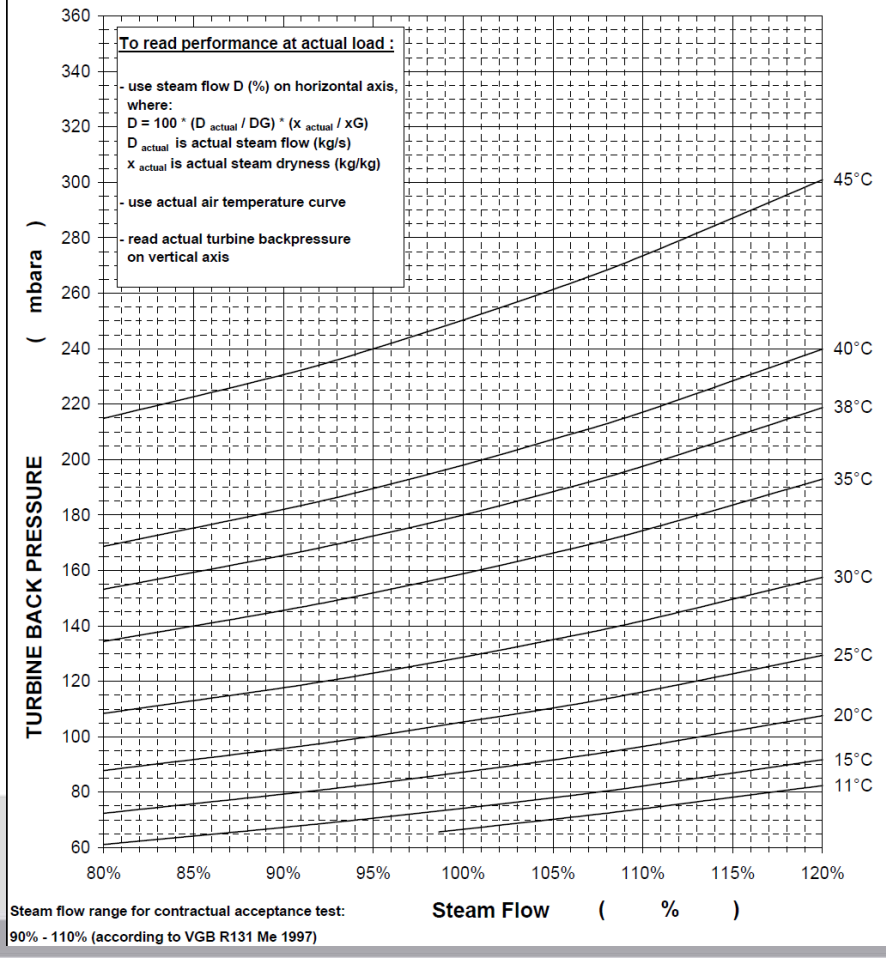
DESIGN CONDITIONS

Steam Flow	DG	297.417 kg/s	Steam Dryness	xG	0.962 kg/kg
Back Pressure	PG	180. mbara	Barom. Pressure	bG	982.4 mbara
Air Temperature	tLG	38. °C	Wind Speed (*) (max.)		3. m/s

(*) 1 m above top manifold level

All Fans at Full Speed

Inlet Air Temperature (°C)



Steam flow range for contractual acceptance test:
90% - 110% (according to VGB R131 Me 1997)

Client	CEA	Document Reference	09-101-0162-032_b1_PCUB0001
Location	Jhajjar (India)		
Document	**PERFORMANCE CURVES FOR CONSTANT DRYNESS**	Proposal Nr	09-101-0162-032_b1

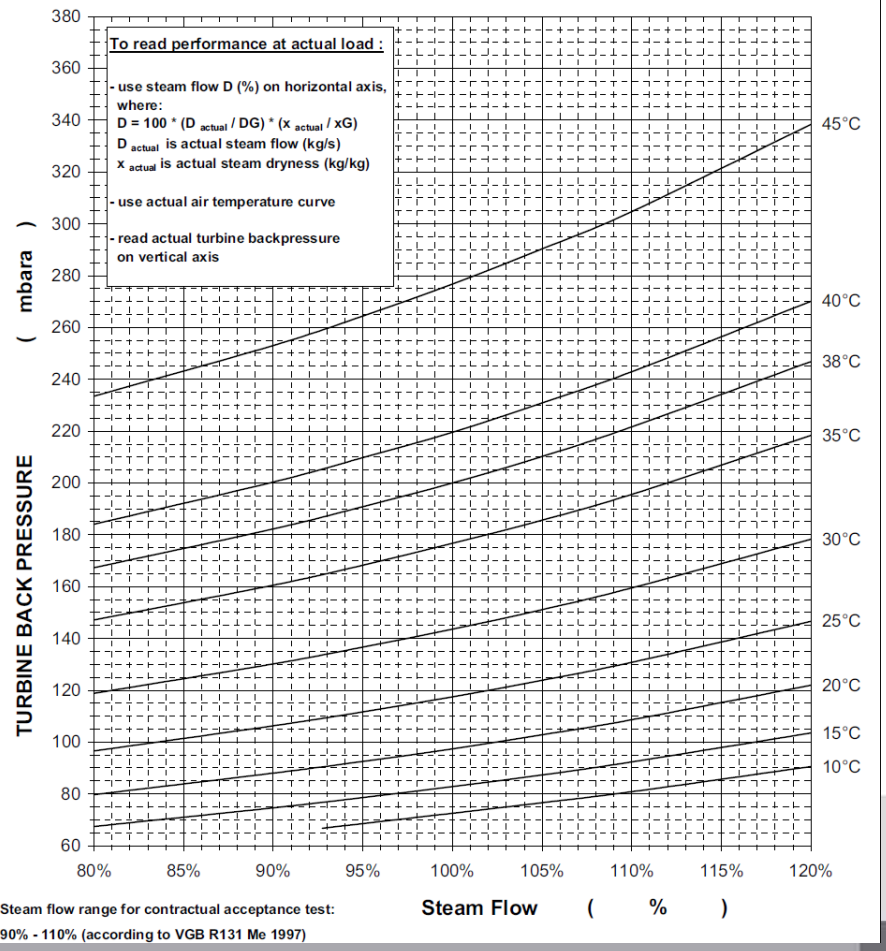
DESIGN CONDITIONS

Steam Flow	DG	298.6 kg/s	Steam Dryness	xG	0.961 kg/kg
Back Pressure	PG	200. mbara	Barom. Pressure	bG	982.4 mbara
Air Temperature	tLG	38. °C	Wind Speed (*) (max.)		3. m/s

(*) 1 m above top manifold level

All Fans at Full Speed

Inlet Air Temperature (°C)



Steam flow range for contractual acceptance test:
90% - 110% (according to VGB R131 Me 1997)

Coal Fired Power Plant - ACC Reference List

Project Name	Type of plant	Country	Plant MW	Year
Zhongyu 2 - Unit 3 (*)	Coal Fired Plant	China	135	2013
Kusile - Bravo	Coal Fired Plant	South Africa	6X690	2012
Wyodak	Coal Fired Plant	USA	330	2011
Midong	Coal Power Plant	China	2X300	2010
Rio Turbio	Coal Fired Plant	Argentina	2X120	2010
Salaqi	Coal Power Plant	China	2X300	2010
Yuanyanghu	Coal Fired Plant	China	2X660	2010
Zhenglan 3 - Shangdu 3	Coal Fired Plant	China	2X600	2010
Baicheng	Coal fired plant	China	2X660	2009
Ewenke	Coal Fired Plant	China	2X600	2009
Hequ	Coal Fired Plant	China	2X600	2009
Jincheng	Coal Fired Plant	China	2X300	2009
LinFen	Coal Fired Plant	China	2X300	2009
Taiyuan 2	Coal Fired Plant	China	2X330	2009

** Selected projects amongst dozens of references*

Dry Cooling

Case Study - Coal
Yuanyanghu (ACC), China

Location – Yuanyanghu Coal Fired Power Plant 2x600 MW - NingXia province, China

Challenge - Fast track delivery and assembly of two units full scope ACC for a 1.320 MW coal fired plant.

SPX Solution – Extended experience in 2x600 MWW units, with more than 20 references in commercial operation; high efficiency SRC ™ finned tubes, A-Frame supported.

Customer Benefit – Commercial operation of Unit 1 in 21 months, from start of design, with successful performance test.

› Dry Cooling

Case Study - Coal
Kusile (ACC), South Africa

Location – Kusile, Coal Fired Power Plant in Mpumalanga province, South Africa . 6X800 MW units for a total capacity of 4.800 MW operated by Eskom

Challenge – Turnkey Project with fan deck at 70 m elevation. Construction activities at height and usage of large cranes are first safety concerns

SPX Solution – "Safety first" has imposed a construction strategy of assembly of large modules on ground floor (up to 135T) and lift with huge crane capacity (850 Ton)

Customer Benefit – Safe site activities, ease of quality inspection, secured construction schedule

Thanks for your kind attention

For queries contact us : Thermax SPX Energy Technologies Ltd, Pune India

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