GAS TURBINE INLET AIR COOLING & WET COMPRESSION

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Boost Power with the cost-effective MeeFog[™] System.



Mee Systems are increasing power output for over gas turbines worldwide today

Alstom Power Rolls-Royce Bechtel Pratt & Whitney Kawasaki KEPCO-Korea Electric Power Corp MHI-Mitsubishi Heavy Industries Ltd. CFE-Commision Federal de Electricidad Empresa Shell Refinery TVA-Tennessee Valley Authority Aluminium Bahrain American Electric Power Black & Veatch British Petroleum DEWA-Dubai Electricity & Water Authority Duke Energy Dynegy GASCO-India Gila River Power Glow IPP Company Ltd. Indian Oil Corporation Malakoff Midland Cogeneration Venture MOE-Ministry of Electricity-Iraq Nijet Services Co. PG&E Portland Gas & Electric Portland General Elect. Praxair Procter & Gamble PSEG Public Power Corp. Greece Raffineria di Milazzo Reliance Energy Ltd SESCO Malaysia Solar Turbines Tampa Electric Company TC Power / RAK GI Nasional Berhad Malaysia Thai National Power U.S. Borax Company Energy Group Wellhead Electric

MeeFog[™] dramatically inc in humid environments

Mee Industries Inc. pioneered gas turbine inlet fogging technology more than twenty five years ago and ever since MeeFog systems have set the standard for cost-effective power augmentation systems. Today hundreds of gas turbine operators around the world use MeeFog to increase power and decrease per-megawatt operating costs. MeeFog evaporative cooling systems can produce a power boost of over 25% in desert climates and wet compression fogging can add another 10% of power augmentation. Even in very humid tropical regions, such as offshore installations, MeeFog systems can produce a power boost of up to 20% with the combined effect of evaporative cooling and wet compression fogging. MeeFog systems have been used by, or approved by, every major gas turbine manufacturer in the world.



MeeFog[™] dramatically increases gas turbine power output even

Without MeeFog[™] you could be losing up to 25% of your power 25 output on a hot day

MeeFog can improve gas turbine output from 10% to 25% anywhere in the world

A critical analysis of weather data shows that, contrary to common thinking, evaporative cooling technology is very effective no matter what the operating temperatures or humidity levels might be. Around the world, from the colder climate of the United Kingdom to the high heat and humidity of Thailand, MeeFog gas turbine inlet air fogging has proven to be significantly more effective and economical than other less versatile methods.

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	ANNUAL	JAN	FEB	MAR	APR	ΜΑΥ	JUN	JUL	AUG	SEP	ост	NOV	DEC
Chicago	20,952	1	15	157	1,303	2,561	3,863	4,036	3,348	2,888	2,069	673	38
Las Vegas	70,306	632	933	3,127	4,012	9,261	11,106	11,051	10,824	9,657	7,137	2,472	94
Orlando	29,634	1,718	1,929	2,666	3,523	3,450	2,504	2,393	2,292	2,379	2,431	2,253	2,096
Bangkok	35,935	3,574	3,103	3,314	3,347	2,939	2,770	2,813	2,768	2,301	2,425	2,971	3,611
Barcelona	12,546	4	28	80	485	1,361	1,933	2,391	2,337	2,015	1,365	485	62
Cairo	41,696	77	325	2,045	4,908	6,106	5,990	5,035	4,719	4,544	4,207	2,865	876
Delhi	51,216	751	1,900	4,897	7,806	8,976	6,984	3,423	2,898	3,791	4,931	3,397	1,462
Frankfurt	10,392	0	0	7	131	1,108	1,970	2,880	2,803	1,250	238	4	0
Geneva	10,661	0	0	4	18	867	2,001	3,107	2,930	1,430	303	2	0
Ho Chi Minh	29,772	3,189	3,142	3,512	3,172	2,637	1,951	1,895	1,903	1,775	1,750	2,146	2,702
Hong Kong	26,221	1,529	1,299	1,531	1,735	1,945	2,106	2,406	2,447	2,736	3,300	3,004	2,184
Mexico	18,768	5	2	316	975	3,287	3,450	2,693	2,699	2,498	2,038	804	0
Riyadh	91,256	412	543	2,973	7,999	11,921	13,428	14,664	14,426	12,060	8,183	3,635	1,013
Singapore	17,313	1,595	1,498	1,708	1,402	1,439	1,485	1,546	1,632	1,377	1,428	1,040	1,162

Evaporative cooling potential throughout the world is impressive when the climatic data is evaluated based on an analysis of coincident wet bulb and dry bulb information. This kind of analysis allows an accurate prediction of peak-power gains, average monthly power gains and peak and average water consumption. Please contact Mee Industries for a detailed report for your gas turbines.



Gas turbine output decreases on hot days when air conditioning loads are highest and power is needed the most. Gas turbine operators understand the reasons—reduced air mass flow and increased power consumption of the compressor—but have long struggled to find a cost-effective solution to the problem.

> We have been operating the MeeFog systems on average 12 hours a day (six days a week) and all four (4) gas turbines have been operating reliably more than 20,000 running hours without observing any abnormalities.

> > - Richard Koedel, Executive Vice President, Amata Power Ltd., Chonburi, Thailand

EVAPORATIVE COOLING DEGREE HOURS OF SELECT CITIES, (°C)

To arrive at the cooling degree hour figures for various locations, researchers at Mee Industries used Typical Meteorological Year weather data, which is an historical collection of 30 year averages of hour-byhour weather data.

Different gas turbines, same MeeFog effect: more power and efficiency

The amount of water required to boost power for a particular turbine depends on the ambient weather conditions and turbine mass flow rate. MeeFog systems inject trillions (10^{12}) of 10 micron water droplets into the inlet air duct. When these super small droplets evaporate they cool the air and increase its density. This in turn results in an increase of air mass flow through the compressor and expansion turbine, which increases power output. Cooler air also requires less energy to compress so the specific work (work per unit mass) of the compressor is reduced. This results in more power being available at the turbine output shaft and a decrease in fuel consumption per megawatt of output power (decreased heat rate).

		WATER AND	POWE	R REQU	IREMENT			
	ISO	NET POWER,	FOG FLOW		NET POWER,	POWER	POWER	
MODEL NUMBER	OUTPUT (MW)	80°F WB/37.8 DB, 26.7 DB)	GPM	LPM	SATURATION (80°F/26.7°C)	INCREASE (KW)	INCREASE (%)	
ALS/ABB GT 8C	52.6	41.2	12.1	45.9	46.1	4,923	11.9	
ALS/ABB GT 11N	83.9	70.4	21.7	82.2	75.3	4,938	7.0	
GE 7111EA	84.9	70.0	20.2	76.6	75.6	5,543	7.9	
GE 7221 FA	161.7	129.7	29.0	109.9	141.3	11,516	8.9	
GE 9171E	125.6	103.1	28.2	106.7	112.0	8,911	8.6	
GE LM2500PH	21.6	15.8	4.3	16.3	18.3	2,460	15.6	
GE LM2500+PK	27.1	20.0	5.4	20.3	23.0	3,026	15.2	
GE LM6000PA	41.0	25.3	8.0	30.4	33.5	8,214	32.5	
Solar Mars	10.0	8.1	2.6	9.9	9.0	891	10.9	
Siemens SGT6- 3000E/W501 D5	109.3	88.7	25.0	94.7	96.7	8,047	9.1	
Siemens SGT6- 5000F/W501 F	171.8	140.6	30.2	114.1	151.9	11,329	8.1	
Siemens W701 F/MHI, W701 F	252.6	206.7	44.7	169.1	223.8	17,123	8.3	
Siemens SGT5- 2000E/KWU V94.2	148.8	122.0	34.8	131.7	132.0	9,947	8.2	

Average water consumption for 20°F (11°C) of inlet cooling with typical gas turbine power increases attainable. Actual numbers are site specific. Ask Mee Industries for a detailed analysis for your application.

Chillers are expensive to install and to operate; media-type evaporative coolers are less expensive but not nearly as effective. Chillers have a significant parasitic power load and both systems impose an inlet air pressure drop, which negatively impacts heat rate even when the systems are not in use. The MeeFog system offers a time-tested, elegant, and inexpensive solution to the problem of gas turbine power augmentation.

	FOG	CHILLER	EVAPORATIVE COOLING	
INSTALLATION COST	\$	\$\$\$\$	\$\$	
OPERATION COST/ PARASITIC LOAD	\$	\$\$\$	\$\$	
MAINTENANCE COST	\$	\$\$\$	\$\$	

High-pressure fogging is the pinnacle of evaporative cooling technology and significantly surpasses older, less-effective and efficient techniques including media-type evaporative cooling units which are severely restricted by ambient temperatures or mechanical chillers with their significant installation and operating costs.

— Gen Lai, Senior Mechanical Engineer, Sanitation Districts of Los Angeles County, CA

countries across continents have discovered the MeeFog \$/kW advantage

Benefits of MeeFog Technology

- Increased power output by 25% or more
- Reduction in NOx emissions by up to 30%
- Reduced cost per kW hour
- Significant fuel savings compared to other systems
- Reduced CO₂ emissions per kW of power
- Improved heat rate up to 5%
- 10% wet compression power boost with 2% overspray
- Most cost-effective way to increase power
- Easy retrofit, only 1–7 days outage for nozzle manifold installation
- Lowest capital, installation and O&M costs compared to other cooling technologies
- Approaches 100% saturation with virtually zero inlet pressure drop
- Greater profitability and faster payback
- Delay capital expenditure by increasing existing generating capacity
- Field tested and proven—over 1,000 installations.

We researched all our inlet air cooling options and found that the MeeFog system was the most technically feasible and the least expensive to install and operate.

Dower boost from evaporative cooling in dry climates.

Cool down, power up with MeeFog

The revolutionary MeeFog system produces billions of micro-fine droplets at 2,000 psi. These tiny 10-micron average sized droplets create a much larger overall evaporative surface, which allows the droplets to evaporate and cool the airflow far more quickly than larger, heavier droplets. This results in faster, more effective evaporation and cooling with significantly lower drain water rates.

power boost from wet compression, regardless of ambient humidity.

We worked with Mee to resolve numerous issues with a fogging system supplied by another manufacturer. Mee recommended installing a redesigned MeeFog nozzle manifold in a new location. When comparing the two systems it is obvious that Mee knows how to design a fogging system for large F-class gas turbines.

— Dan Turley, Portland General Electric, GE-7FA Operator, Portland, OR



WINDOWS & LIGHTS

Micro in size. Macro in benefits.

The world's most highly engineered, high-efficiency, high-pressure impaction-pin water atomization nozzle is made exclusively by Mee Industries. Each nozzle is made with exacting precision from high-grade stainless steel in our own factory, then individually tested and adjusted to exacting standards before it is installed in a MeeFog[™] system. The standard MeeFog nozzle features a 0.006 inch (150 micrometer) diameter orifice which produces billions of ultra-fine droplets per second. At an operating pressure of 2000 psi (138 bar), the average droplet produced is less than 10 microns, or about one tenth the diameter of a single strand of hair. This results in rapid evaporation so 100% efficient evaporative cooling can be accomplished in just a few seconds, with less wetting of duct surfaces and greatly reduced inlet air pressure drop. The MeeFog impaction pin nozzle set the industry standard worldwide for inlet fogging nozzles and has been proven to consistently out perform all other high-pressure nozzles. With properly treated water, the MeeFog nozzles have a useful life of more than 30 years.

IMPACTION-PIN Micro-machined tip, TIG welded to nozzle base.

O-RING SEAL

NOZZLE LINE Meets ASME 31.1 Power Piping Code

FOG DROPLET DISTRIBUTION



NOZZLE FILTER 40 micron particle size, replaceable, last chance filter.

TUBE ADAPTER 316 L stainless steel TIG welded to tube



The ultra-fine droplets (10 microns or less) produced by MeeFog impaction pin nozzles mix with airflow faster and evaporate faster than droplets produced by other fog nozzles. Swirl-jet nozzles in particular produce much larger droplets and have more water flow in a smaller spray plume which inhibits evaporation and results in excess unevaporated water.

The MeeFog Nozzle: Micron droplets, elegant design, exceptional efficiency, unrivaled performance



can be quickly modified for specific applications. Pump skids include programmable logic controller (PLC) with easy to use software. Pump skids and high-pressure feedlines can be installed when the gas turbine is in operation. Nozzle manifold installation requires 1 to 7 days of outage

MeeFog **High Pressure Pump Skids**

- Pre-engineered for quick delivery
- Field tested & proven
- All wetted parts are non-corrosive material
- 140 to 210 bar (2000 to 3000 psi)
- Durable polyurethane paint finish
- Pumps run at low speed for long life
- Programmable logic controller (PLC) with interface panel
- Easy to use, opensource software
- Easy connectivity to PC in control room
- Weather station for automatic operation
- · Oversized inlet water filter, 0.35 micron particles
- Discharge filters (10 micron) prevent nozzle plugging from pump seal material
- Small enough to be airfreighted for fast-track projects

For turnkey solutions from design to installation, turn to Mee

Whatever your challenge, whatever your application, wherever your location — Mee Industries is exceptionally experienced and uniquely able to understand the specifics of your situation and design a solution for maximum performance and efficiency. Mee provides precision-engineered, turnkey solutions for even the most demanding application or project. Our position as the global leader in high-pressure fog technology means we work closely with gas turbine operators around the world to meet special project requirements, including accelerated delivery schedules, and to provide our valued customers with highly responsive after-sales support. We take great pride in meeting deadlines, our company-wide success metric is, "projects completed on time".

DESIGN, FEASIBILITY STUDY & ROI

Our engineering team can assist you to design a fog system that meets your needs. We can provide feasibility studies and a detailed return on investment analysis that will assist you in your decision making process.

PROJECT DRAWINGS AND DOCUMENTATION

Once an order is placed, Mee Industries will begin the process of developing project drawings and documentation, consisting of schematics, wiring diagrams, P&IDs, general arrangement drawings and installation instructions.

PROJECT MANAGEMENT

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Each MeeFog project is assigned a project manager to communicate with the customer, track the progress of the project, and to ensure that any project bugs get fixed quickly.

MANUFACTURING

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Mee is committed to the highest manufacturing standards. We are an ISO 9001:2008 certified company and pride ourselves on our quality management processes. All MeeFog electrical panels are made in-house to meet UL, CUL & CE specifications and we continually look for ways to improve both our manufacturing process and the quality of the products we build.

SHOP TESTING

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Every fog pump skid is given a full operational test using a specially designed testing rig. All control algorithms are checked to ensure fully functional skids arrive at the project site. Fog nozzle lines are also shop tested to check for leaks in welds and to ensure they meet our stateof-the-art manufacturing guidelines.



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INSTALLATION/COMMISSIONING

Mee understands that gas turbine downtime costs money. That's why our MeeFog[™] turnkey systems are designed to be installed as quickly and economically as possible—dramatically minimizing downtime. Typical installations require only 1–7 days of outage.

CUSTOMER SUPPORT /PARTS SALES

Your Mee Customer Support team is committed to helping you keep your fog system running effectively, efficiently and economically with customer support that is fast and professional. Whether you need parts, answers to technical questions, or field service, our tech support staff will be standing by to help. We are committed to keeping your MeeFog System running at optimum capacity and efficiency and to making the overall experience of dealing with us a pleasant and positive one.

Water Treatment

by Mee

Purified water is an important element of a successful fog system installation. Water treatment skids by Mee are built to fully integrate with fogging skids.

Mee water treatment systems use a combination of 2-Pass reverse osmosis and electro-deionization to remove minerals and dissolved solids from supply water.

RO-EDI systems can also be used to supply makeup water for boilers, compressor washing and NOx injection.



Mee the world leader in high-pressure fog technology

International project capabilities

Mee Industries has been doing business around the world since the company was founded. Our international sales executives and extensive network of sales agents make it easy to do business with us.

Mee Industries has a strong relationship with the Export-Import Bank of the United States which allows us to finance large projects with international companies and governments, often without letters of credit or down payments.

Our experienced finance team can handle even the most complex international transactions and we have successfully completed turnkey projects in many developing countries under difficult working conditions.







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Mee Industries is a privately held company with corporate headquarters in Irwindale, California.



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