MeeFog Systems

WET COMPRESSION POWER AUGMENTATION

Boost Gas Turbine Power with MeeFog™

Why MeeFog?

Nearly instant power boost of up to 20%

Wet compression is a gas turbine power augmentation method that consists of injecting atomized water (fog) directly into the gas turbine compressor. The droplets evaporate inside the compressor, giving an intercooling effect that reduces the work of compression. Since the compressor consumes less power, more power is available at the output shaft and the gas turbine output increases. Wet compression systems produce a power boost beyond that available from gas turbine inlet-air cooling. The power boost does not vary with changes in ambient temperature or humidity and it's available whenever the temperature is above about 45°F (7°C).

Wet Compression Boost Chart

Turbine Model	ISO Output (MW)	No Fog (MW) [1]	Wet Compression at 1% of Air Mass Flow				Wet Compression at 2% of Air Mass Flow			
			Output (MW)	Boost (MW)	Fog Flow (gpm)	Fog Flow (m3/hr)	Output (MW)	Boost (MW)	Fog Flow (gpm)	Fog Flow (m3/hr)
GE Frame 6	40.34	36.83	40.4	3.5	21.9	5.1	43.39	6.55	43.68	10.18
GE 7EA	84.92	77.53	84.7	7.2	46.6	10.87	90.91	13.38	92.98	21.68
GE 7FA	174.6	159.56	172.7	13.1	71.3	16.61	184.05	24.49	142.16	33.14
MHPS 501F	188.29	172.42	186.1	13.7	73.5	17.13	193.19	20.77	146.62	34.18
GE GT-11N	115.4	106.11	117.0	10.9	63.1	14.71	126.67	20.55	125.92	29.35
GE GT-13E2	172.3	157.54	172.2	14.7	84.6	19.72	184.90	27.36	168.83	39.35
P&W FT8	25.6	22.74	25.5	2.7	13.1	3.06	26.67	3.92	25.97	6.05
Siemens SGT5-4000F	188	170.09	184.1	14.0	87.0	20.29	195.20	25.11	173.51	40.45

[1] Output at 75 °F and 100% relative humidity

Large power boost

The water-flow rate of a wet compression system is often expressed as a percentage of the turbine air-mass flow. The power boost for 1% wet compression ranges from 8% to 10%. MeeFog has installed wet compression systems that flow as much as 2.5% of the air-mass flow.

Very cost-effective solution

The MeeFog System is a very cost-effective way to increase gas turbine power output. Installed costs are typically less than $100/kW.

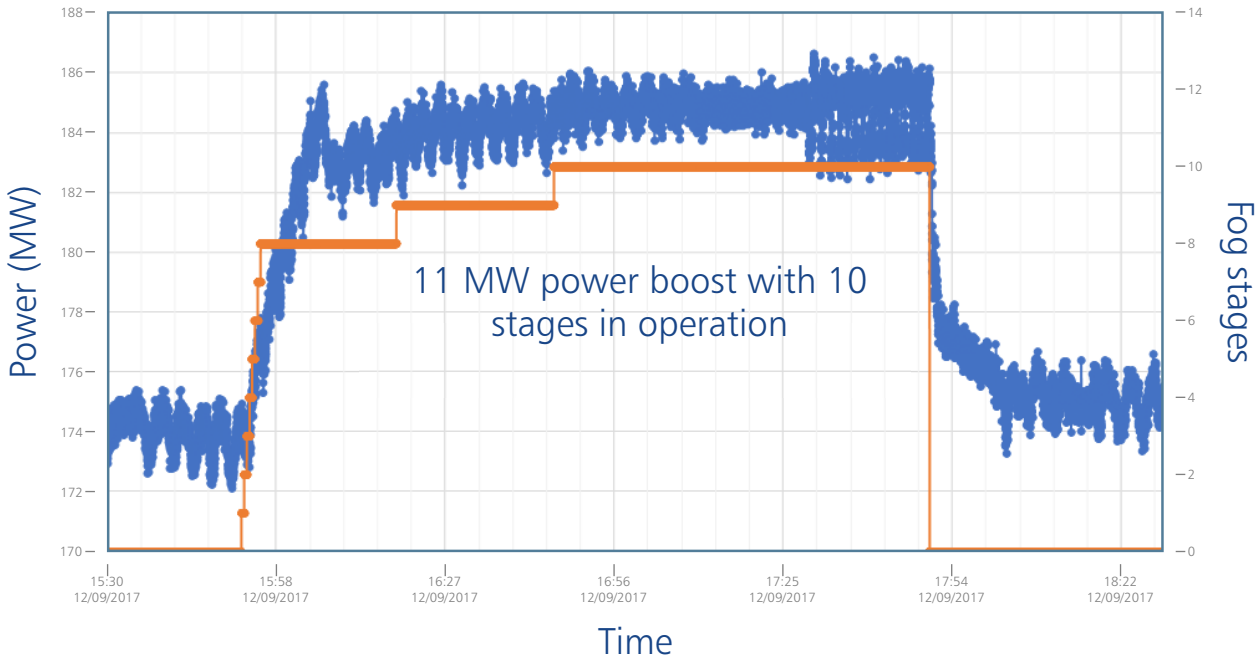
Fast project execution

Mee Industries offers pre-engineered skids, which are small enough to be air freighted. Skids and feedlines can be installed while the gas turbine is in operation. Nozzle-manifold installation requires an outage of 1 to 4 days. Projects can be completed as quickly as 20 weeks from the date of order.

Decades of experience

The first MeeFog wet compression system was installed on a GE 7EA turbine in 1995. Today there are more than 300 MeeFog wet compression installations on turbines ranging from small aeroderivites all the way up to the 269 MW GT26 turbine.

Results of a Wet Compression Test



Test results based on 10 out of 14 stages of wet compression

Operational benefits of MeeFog

- Nearly instant power boost of 20% or more.
- Power boost available whenever ambient temperature is high enough that there is no risk of freezing at the compressor inlet.
- Very small droplets allows tens of thousands of hours of operation without significant blade erosion.
- Improve heat rate up to 10%.
- Significant fuel savings compared to other augmentation systems.
- Reduction in NOx emissions by up to 30%.
- Reduced emissions per kW of power.
- Lowest capital costs and fastest payback compared to other power-augmentation technologies.

"We are probably the longest running wet compression user in the world in terms of total hours, having successfully used wet compression for more than twenty years. We run the MeeFog Systems round the clock during the peak period of electricity generation from June to September and anytime the ambient temperature is as above 50° F."

-Steve Ingistov, Principal Engineer, Watson Cogeneration
(Fog systems installed in 1998.)

Controls modifications

Wet compression reduces the combustion temperature, which can lead to increased CO emissions. To get the full benefit of wet compression, and to keep CO emissions within permitted limits, it is best to modify the GT fuel controls to bring the combustion temperature back to where it was without wet compression. Mee Industries can arrange for controls mods, or recommend several third-party controls companies who have experience with these mods.

The combustion temperature goes down because wet compression adds water to the inlet airflow. The added water vapor increases the specific heat of the working fluid which means there is less cooling during the expansion process. This causes the exhaust temperature to increase, even though there was no increase in the combustion temperature. The GT controls misinterpret the increased exhaust temperature as an increase in combustion temperature, so fuel flow is reduced. The result is a lower combustion temperature than there was without wet compression.

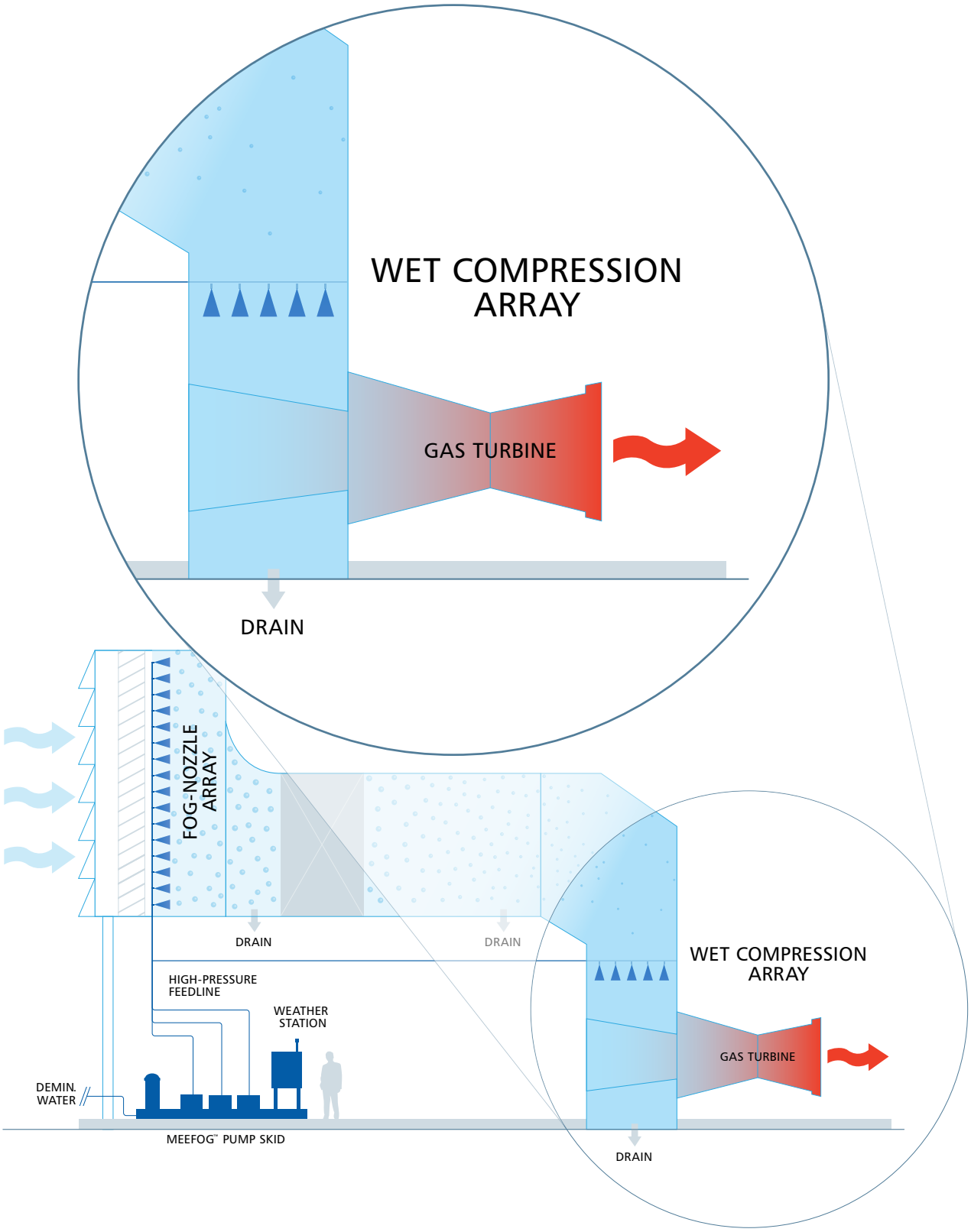
When doing more than about 0.5% wet compression, fuel-controls modifications will keep CO emissions from going too high and will ensure that the full power boost is realized. When wet compression is in operation, the GT switches to a "wet-control curve" and a higher exhaust temperature is targeted, in order to keep the combustion-temperature the same.

Load following with wet compression

Wet-compression systems can be configured with many stages of water output, with each stage producing a predictable power increase; one megawatt per stage fog for example. This allows the wet-compression system to be used to increase or decrease GT output by adding or removing fogging stages. The wet-compression system can also be connected to an automatic generation control signal, so the system automatically ramps up and down to deliver power when needed.

The MeeFog pump skid provides high-pressure water to fog nozzle manifolds located close to the inlet.

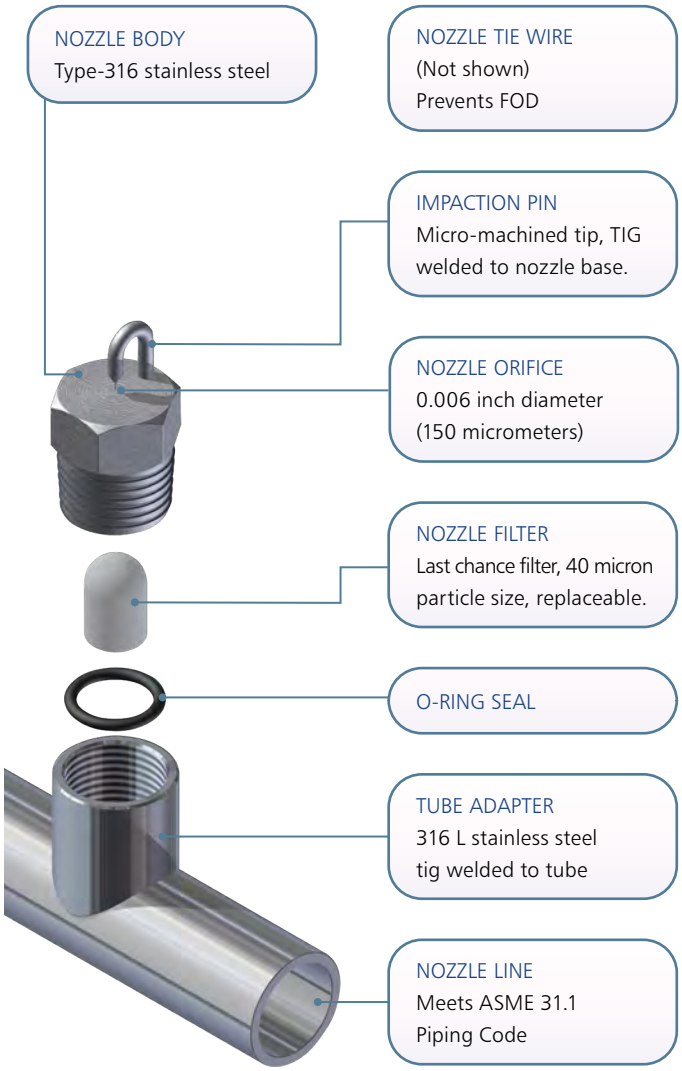
Inlet-Air Fogging Installation



10-Micron Droplets with MeeFog Systems

Micro in size. Macro in benefits.

The tiny droplets from a MeeFog nozzle evaporate quickly. The average droplet produced by a MeeFog nozzle is less than 10 microns, about one tenth the diameter of a single strand of hair. Typical operating pressure is 2000 psi (138 bar). Air-pressure drop through the nozzle manifolds is negligible.



The MeeFog nozzle has been shown to consistently outperform other high-pressure nozzles. They have a useful life of more than 30 years when used with properly treated water.

Importance of small droplets

If the wet-compression spray is made up of large droplets, it can erode the compressor blades through a process called liquid-impaction erosion.

Large droplets can cause micro fractures in the metal surface, which eventually leads to pitting. For example, using an online water-wash system to get a wet compression power boost can lead to as much as 1/4" of material being removed from the leading edge of the blades in less than a year of operation.

The MeeFog System produces a fog spray with 90% of the water flow in droplets of 20 microns or less. They have been shown not to produce significant blade erosion.

"We have operated our MeeFog wet compression system for 12,000 hours with only very slight erosion of the first row of compressor blades."

- 501F gas turbine user

MeeFog High Pressure Pump Skid

Pump skid

- Stainless-steel welded frame – easy access for maintenance.
- Oversized inlet water filter, with 0.35-micron cartridge filters.
- Discharge water filters (10 micron).
- All wetted parts are non-corrosive material.
- Water-lubricated, direct-drive pumps. No oil or drive belts to change. Operates 8,000 hours between rebuilds.
- TEFC severe duty electric motors.
- Motor Control Panel / PLC Control Panel available in NEMA 4X.

Controls

- Weather station for low temperature cut-off.
- Programmable logic controller (PLC) with interface panel.
- Easy to use, open-source software.
- Easy connectivity to DCS and/or PC in control room.

The MeeFog Advantage: Experience Based in Science and Innovation

For over 50 years Mee Industries Inc. has been the leader of innovative water-fog technology. MeeFog Systems are used to humidify and cool industrial, commercial, and agricultural processes and to create dynamic special effects.

Thomas Mee Jr. who founded Mee Industries in 1969 started his career as a Cornell University research scientist. The company originally manufactured high-tech, meteorological instruments. The first MeeFog Systems were used to study natural cloud phenomena. By the early 1980's, high-pressure water fogging had become the company's main focus. Our active research & development effort ensures that we are continually improving our technology.

Today the company is owned and operated by Thomas Mee III and D'Arcy Mee Sloane, who continue their father's tradition of running an innovative and ethical company for the benefit of customers and team members.

The MeeFog team looks forward to discussing your project with you.

MeeFog Systems

Mee Industries Inc. 16021 Adelante St. Irwindale, CA 91702
T: 626.359.4550 • info@meefog.com • www.meefog.com

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