ANTI-ICING/AIR INLET HEATING GUIDELINE

Option	Location	Protection	Heat Capacity	Functionality	Pros	Cons
Hot Air: Compressed Bleed	Upstream or downstream	• Filter de-icing • Turbine foreign object damage (FOD) protection	Limited by the OEM spec. Target is to heat the air by +/- 10°C (18°F)	Hot air is sent through pipes from the gas compressor bleed, and is distributed through anti-icing rakes in the opposite direction of the airflow.	• Plenty of hot compressed air is available directly from the turbine • Small extra system for feeding hot air: pipe that goes from the turbine to the air intake • Can be cost effective especially on large turbines, compared to the other solutions • Relatively low pressure drop	• Turbine needs to be in operation – not for startup • Reduces power output from turbine ~-2% • Hard to get even spread, hot spots (verify downstream components operating temperature) • Sound needs to be reduced by silencers on each nozzle, under 85 dBA
Hot Air: Ventilation	Upstream	• Filter de-icing • Turbine foreign object damage (FOD) protection	Limited by heat radiated by the engine in the enclosure: Target is to heat the air by +/- 10°C (18°F)	Ventilation air from the enclosure is reused through a ducting system to warm the incoming air. Electrical heaters may be required to increase the temperature if the air is not warm enough.	• Free heat source, if extra heater not needed • Relatively low pressure drop	• Turbine needs to be in operation – not for startup • Too little heat in ventilation air, especially for heavy-frame turbines. Extra electrical heater may have to be installed to boost heating. • Extra pressure drop for the ventilation fan • Larger footprint: extra hardware such as fans, dampers, ducting required, complex installation
Hot Air: Exhaust	Upstream	• Filter de-icing • Turbine foreign object damage (FOD) protection	Unlimited: Target is to heat the air by +/- 10°C (18°F)	Ducts, dampers, and fans direct hot air flow from the exhaust, mixed with ambient air to the inlet.	• Plenty of hot air available from the exhaust • Free heat source • Relatively low pressure drop	• Turbine needs to be in operation – not for startup • Difficult to retrofit, extra ducting from exhaust system • Larger footprint: extra hardware such as fans, dampers, ducting required, complex installation • Proper design is required for effective temperature distribution
Heat Exchanger: Heating Coils	Upstream or downstream	• Filter de-icing • Turbine foreign object damage (FOD) protection	Limited by heat source availability: Target is to heat the air by +/- 10°C (18°F)	Heating coils pump fluid to heat inlet components and can be operational even before starting the engine.	• Even spread of heat • Low operating cost • Different working fluids can be used (Water/Glycol, Oil, Steam)	• Could be difficult to implement, extra system needed to control and generate feed hot water • Coils are relatively expensive • Pressure drop over the heating coil, compared to other solutions • Coils could lose effectiveness over time as they foul (loose efficiency overtime, regular maintenance required to keep it clean)
Electrical Resistance	Upstream or downstream	• Filter de-icing • Turbine foreign object damage (FOD) protection	Limited by electrical power availability. Target is to heat the air by +/- 10°C (18°F)	An electrical heater is used to prevent freezing and increases in the air temperature.	• Heat available at all time • Even spread of heat • Easy to install, driven by electricity • Relative easy to retrofit	• High operation cost • Adds pressure drop • Requires electric source
Pulse System	Filter protection only	• Filter de-icing	None	Cartridges pulse snow and thin ice off filters.	• Cost-effective anti-icing system compared to a static filter solution • Can maintain a low pressure drop through self-cleaning operations • No need for special heat source, easy to implement	• Limited impact on protection • Doesn't heat the air and does not prevent FOD (ice) • Performance varies depending on ice and snow conditions
Heat Surface: Infrared	Surface protection only	• Filter de-icing	Limited by electrical power availability. Heats only the surface to 20-30°C (68-86°F) and does not heat the air	Infrared heaters are installed in front of filters to prevent ice formation. They heat the surface by radiation and do not heat the air significantly.	• Effectively prevents ice formation on filters directly exposed infrared • Even spread of heat • Easy to install, driven by electricity • Easy to retrofit	• Limited impact on protection • Doesn't heat the air and does not prevent FOD (ice) • Requires electric source
Heated Vanes	Vane protection only	• Filter de-icing	Limited by electrical power availability. Target is to heat the vane surface - can heat the air by 2°C (3.6°F) max	Vanes are heated by an electrical heating cable to prevent freezing and allows drainage of collected water.	• Effectively prevents ice formation and snow accumulation on vanes • Even spread of heat • Easy to install, driven by electricity • Easy to retrofit	• Limited impact on protection • Heat the air approximately 2°C (3.6°F) max • Does not prevent FOD (ice) • Requires electric source

Upstream: placed in front of the air inlet filter system
Downstream: placed behind the filters and protects only the bellmouth

	Hot Air: Bleed	Hot Air: Ventilation	Hot air: Exhaust	Heating Coils	Electrical Resistance	Pulse Filters	Infrared	Heated Vanes
CAPEX	3	2 - 3	3 - 5	2 - 4	3 - 4	1	2	2 - 4
OPEX	3 - 4	2	2 - 3	3 - 5	3	1	1	1
Ease of Retrofit	5	5	5	3 - 5	2	n/a	1	1

CAPEX & OPEX: Range: 1-5 (1 being the least expensive, 5 being the most expensive)
OPEX: impact of operation on gas turbine performance + cost of running + maintenance

This is a general guideline. Please contact your local Camfil representative for specific applications.