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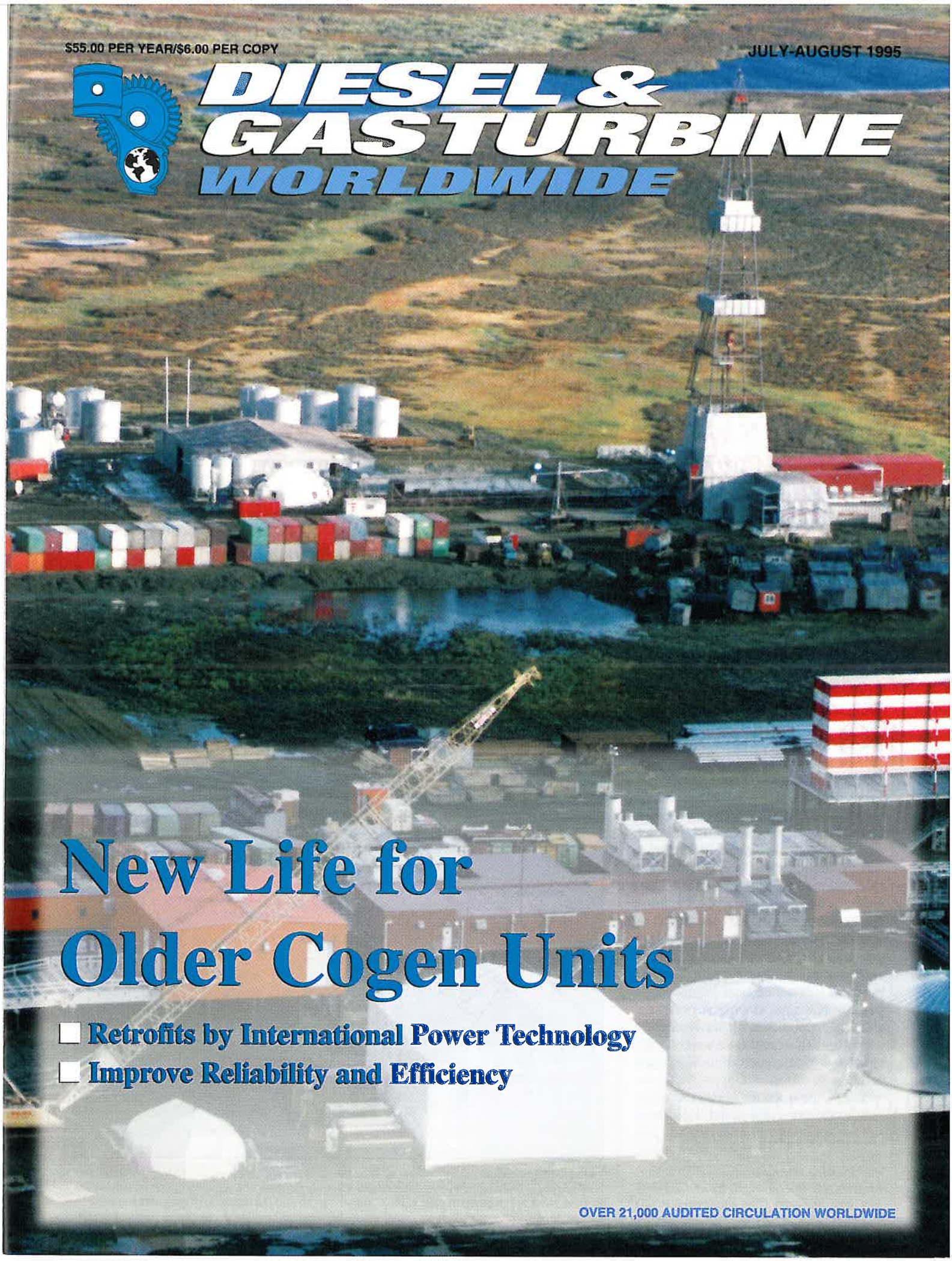
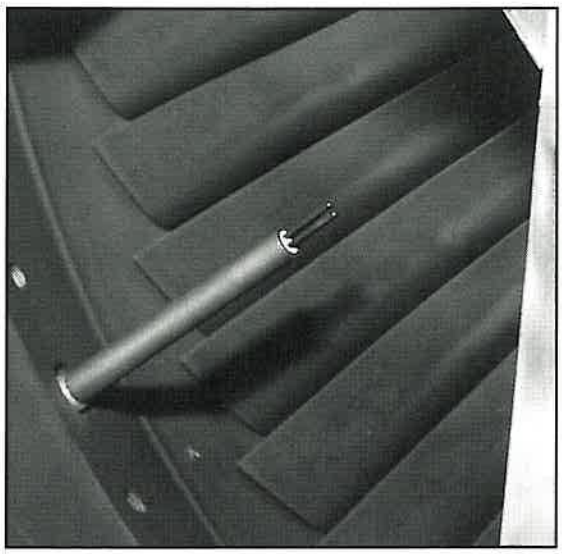


New Life for Older Cogen Units

- Retrofits by International Power Technology
- Improve Reliability and Efficiency

OVER 21,000 AUDITED CIRCULATION WORLDWIDE



Turbine outlet temperature thermocouple retrofit installation significantly improves the operating life of turbine exhaust temperature thermocouples and lowers operating costs.

COGENERATION UPGRADES — THE TIME IS RIPE IN CALIFORNIA

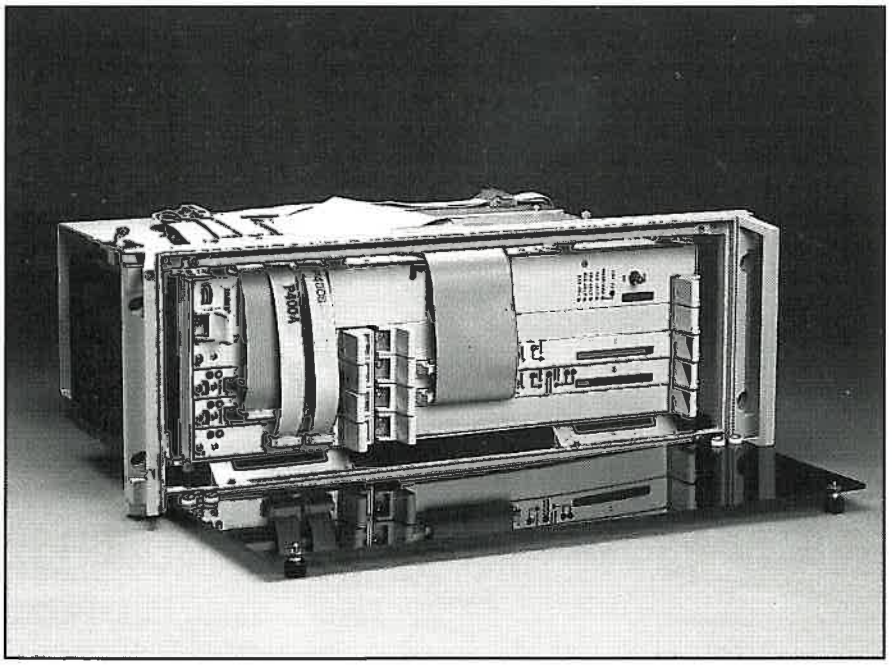
By Sharon R. Fournier and Richard A. Bitting, P.E.

FROM 1980 to 1986, the number of cogenerators and private power producers in California grew from a handful to more than 1250. Much of the increased activity in cogeneration was a result of the United States' Public Utilities Regulatory Policies Act of 1978 and related Federal Energy Regulatory Commission regulations, intended to improve energy efficiency nationwide. The high buyback price for electricity available at this time made cogeneration very attractive. Many independent cogeneration plants in California installed during this "Gold Rush" era have now been in service ten years or more. Advances in control technology and engine hardware made over the last ten years, as well as a better understanding of application needs, enable retrofit work to improve the thermal and economic performance of mature cogeneration plants. The time is ripe for retrofitting these plants with new parts or equipment to extend their useable lifetime and to increase their economic efficiency.

With a life of 20 to 30 years or more, energy facilities represent a significant investment. Therefore, keeping facilities up-to-date is a sound capital investment, extending the life of the plant and increasing its economic efficiency. The following is an overview of several retrofit projects with which International Power Technology has recently been involved. Included is a discussion of the technical as well as economic logic behind each decision to retrofit. Most of the projects discussed here have a payback period of one to two years.

International Power Technology (IPT), an energy service company in Foster City, California, has over 500,000 hours of plant operating experience, and is well acquainted with the benefits and challenges of cogeneration. IPT offers a broad range of services to parties interested in cogeneration, independent power, and thermal energy production. These activities can be tailored to the specific needs of a facility or plant owner, and include retrofit services.

One of the first of the company's retrofit projects involved conversion of several gas turbines from turbine inlet temperature (TIT) control to turbine outlet temperature (TOT). The plants affected by this retrofit were: a two-unit, 11.2 MW cogeneration facility at the Sunkist Growers fruit processing plant in southern California, a 5.6 MW unit at SRI International, a research facility in the San Francisco Bay Area, a 5.6 MW unit at San Jose State University, a 5.6 MW unit at the Frito-Lay food processing plant in Kern County, and another 5.6 MW unit at the Hershey Chocolate plant in Oakdale. All of the facilities have the Allison 501-KH engine, which at the time of their construction was only available with TIT control. While directly measuring the engine operating temperature, TIT thermocouples need



The new digital engine control system used in the turbine outlet temperature retrofit projects. This control system is produced by Precision Engine Controls for these IPT retrofit projects on Allison gas turbines.

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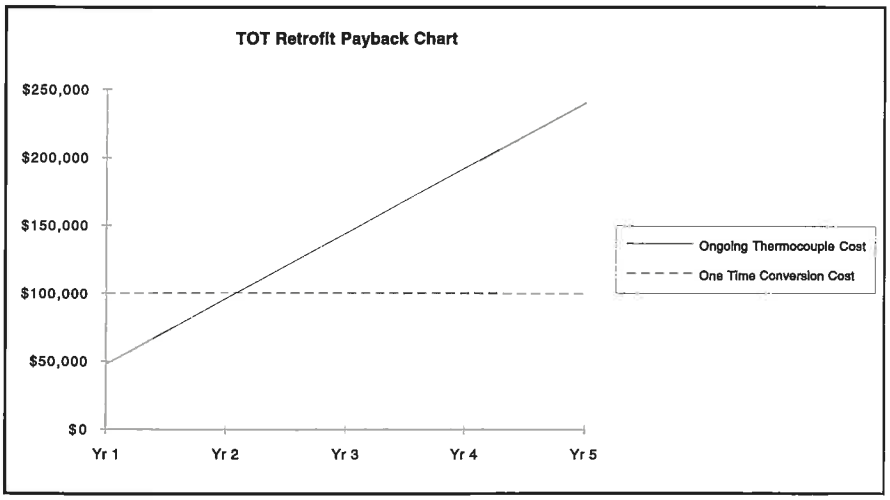


Payback chart on turbine outlet temperature retrofit shows how quickly this retrofit investment pays for itself, within about two years or less.

to be frequently replaced due to their high operating temperature. Using TOT thermocouples greatly reduces operating costs because their relatively low temperatures (535°C, as opposed to 1035°C with TIT control), affords them a much longer life.

This upgrade involved modifications to the engine hardware and the engine fuel control system. Engines lacking a rear turbine outer casing compatible with TOT thermocouples were upgraded. The installation of the thermocouples themselves was a comparatively simple procedure. Thermocouples and engine hardware were obtained from Allison Engine Company. More complex modifications were made to the engine control system.

The existing analog engine control system, manufactured by Bendix, was completely replaced with a digital system manufactured by Precision Engine Controls Corporation of San Diego. The TCSD system is a state-of-the-art design providing the flexibility of a computer-based system, along with the safety of built-in backup speed and temperature protection. The new digital rack required a major change in the interconnecting wiring and logic in the rest of the plant control systems.

Prior to the retrofit, the cost of TIT thermocouple replacement was approximately US$4000 a month, one of the project's greatest ongoing operating expenses. In addition to allowing for the TOT conversion, the new digital control system provides a more reliable and flexible control that helps to improve plant availability. This modification helps the plants to achieve maximum efficiency, reliability, and economic performance.

IPT manages the operation of a 2076 kW cogeneration plant at California's Correctional Training Facility in Soledad. This facility uses two Waukesha VHP 7042GSI natural gas engines, both of which run at 1038 kW output. During its first year of management, IPT performed several significant retrofits to the Soledad plant. One retrofit involved modification of the waste heat boiler. IPT installed two additional risers, which reduce back pressure on the boiler, improving circulation and reducing tube warpage in the generating modules.

Another upgrade was to the engine cooling system. This involved the installation of two heat exchangers to reduce the potential for detonation induced failures and provide better isolation of the heat source water from the process water. Also installed were utility-grade electrical meters and Btu totalization meters for thermal monitoring in order to improve accounting. To improve plant safety and protection, shutdown devices were added for low boiler water level, jacket water rapid decompression, and engine main bearing over temperature. In order to increase longevity, reliability and efficiency, IPT also replaced the magneto style ignition with a newer electronic ignition and modified the controls to automatically follow site load.

Recently, the company also designed and commissioned a nozzle steam injection retrofit for Frito-Lay at their 5.6 MW cogeneration unit in Kern County, California. This system supplies saturated steam through the engine fuel nozzles, which affords Frito-Lay greater operating flexibility, while still meeting strict air quality regulations. Nozzle steam injection is an easily maintained system which presents the operators with little additional maintenance requirements. Even though nozzle steam represents new use of plant steam, the amount used is easily offset by a decrease in the amount normally used for power production. The IPT-designed system used engine hardware supplied by Allison Engine Company.

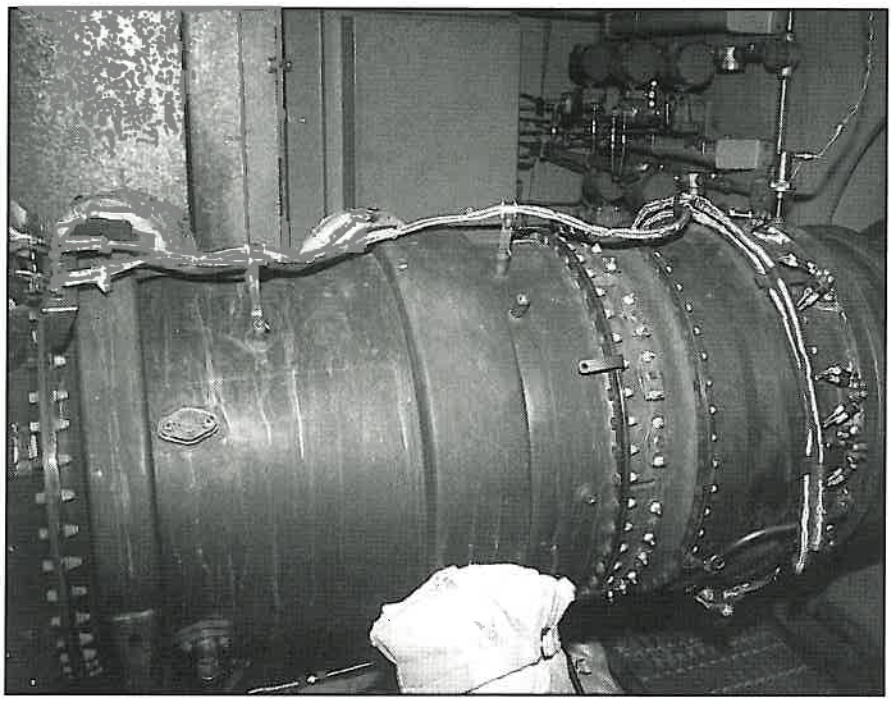
Of the various technologies available to Frito-Lay, nozzle steam injection had the lowest heat rate (least specific fuel consumption), resulting in the lowest fuel cost per kW produced. In planning the installation of the nozzle injection system, the amount of plant downtime and interruption was kept to a minimum. Most of the piping and electrical installation was completed ahead of time, resulting in no additional downtime for the actual installation.

IPT evaluated NO_X control techniques in a recently completed engineering study of the City of Santa Clara's Cogeneration Plant 1. The Bay Area Air Quality Management District published new regulations in 1994, which lowered allowable emission levels of oxides of nitrogen (NO_X) for stationary gas turbines. The City of Santa Clara was, in effect, mandated to modify its plant if it was to continue in operation beyond the effective date of the new requirements. The city's cogen plant is a two unit facility that supplies electricity to the city's own distribution system and to an adjacent paper manufacturer. The plant was built in 1983 and uses two Allison 501-KB engines.

The city's situation is similar to that of a number of other plant owners. When faced with stricter air emission standards, responsible parties often find it beneficial to authorize a study by experienced plant managers and design engineers. The City of Santa Clara commissioned IPT to perform a study of emission control options which would satisfy the regulatory requirements. The study assessed the various technologies available in regard to their capital cost and effect on plant operation. Currently available technologies included water injection, steam injection, and selective catalytic reduction (SCR). Technologies that may be available sometime in the near future included advanced dry low-NO_X combustion systems. IPT's analysis found that the two best technologies for this plant were water injection and nozzle steam injection. The city is currently proceeding with a water injection retrofit.

In order to justify the large capital expense of the modifications to the gas turbines and their auxiliary systems required to meet the new emission levels, the city decided to make other plant improvements to increase output and extend plant lifetime. IPT's study also evaluated these modifications and costs. Other recommended upgrades included: engine hardware improvements, control system upgrades, generator rerating and water treatment system improvements. All of these upgrades were justified based on an economic analysis and most of the improvements are now being implemented.

IPT also provided Hershey Chocolate Company's 5.6 MW cogeneration facility with control logic that enables them to cut back internal electrical load when utility supplies are unavailable. This allows the plant to reliably supply all electrical needs in emergency situations. This type of system is useful to plant owners when the utility electrical supply is unreliable and in-house generation is less than the peak demand. Traditional approaches using underfrequency detection do not always react quickly enough, and also make it difficult to prioritize different subfeeders. This system makes it easy to rapidly shed load based on a predetermined schedule, preventing an overload condition which would result in a complete plant blackout. This system provides an attractive payback on the basis of even one avoided plant outage. ■



Allison 501-KH gas turbine hot section showing the new turbine outlet temperature harness installed.