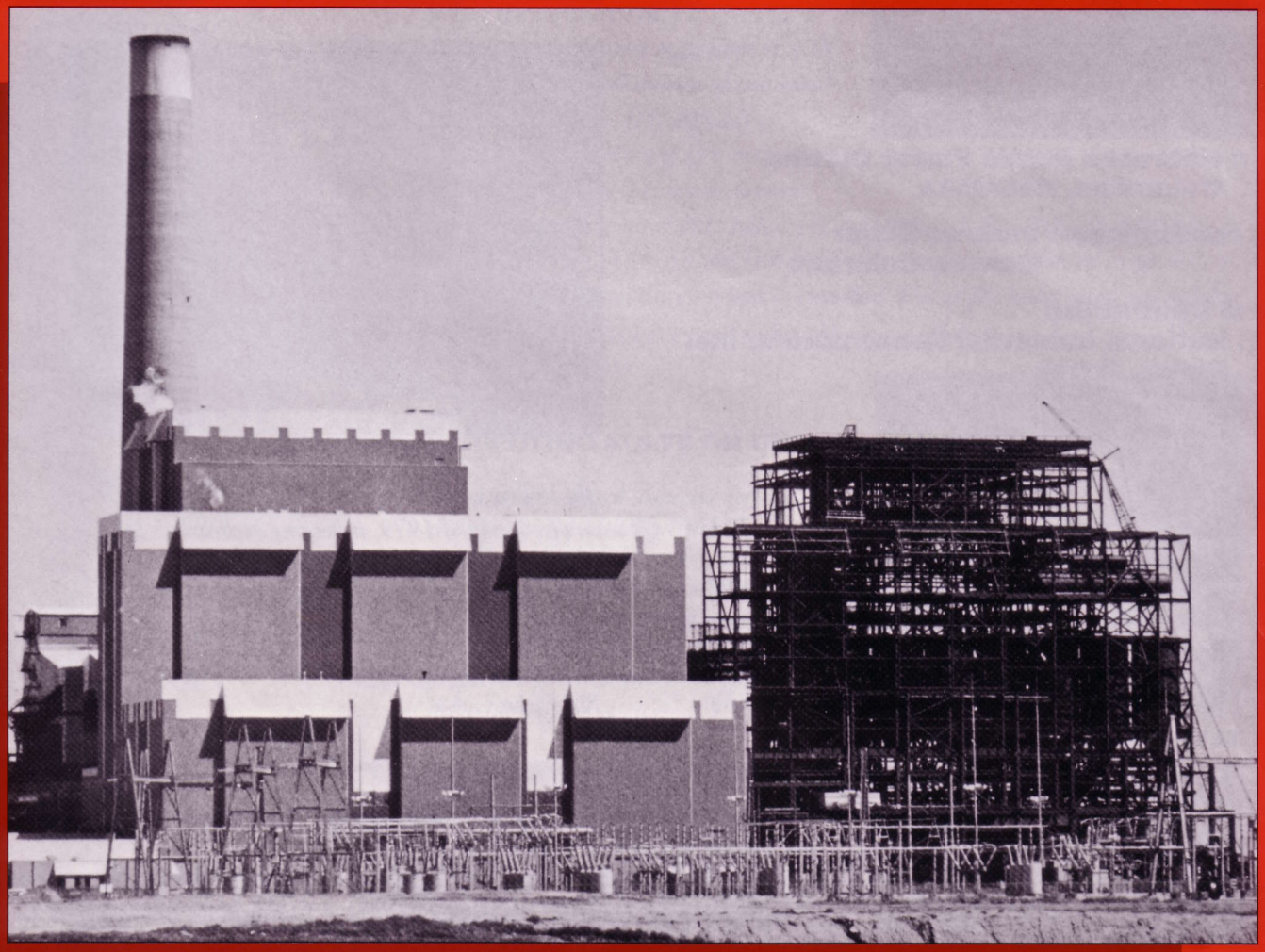
DTI CASE HISTORY

# GERALD GENTLEMAN POWER STATION



**High-strength bolts with Direct Tension Indicators save more than $150,000**

**DIRECT TENSION INDICATORS TO ASTM F959**

(Patented)

**J&M Turner Inc.**

# At Gerald Gentleman Unit 2... Direct Tension Indicators Save Five Times Their Initial Cost

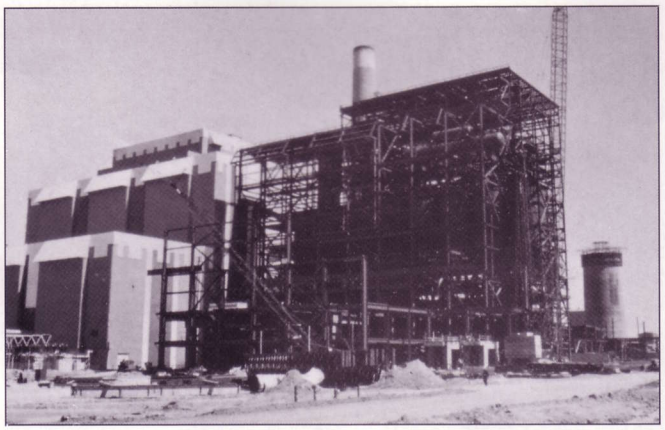
**GERALD GENTLEMAN POWER STATION**
**Sutherland, Nebraska**

**Unit 1**
**Unit 2**

**Owner: Nebraska Public Power District**
**Columbus, Nebraska**

**Architect-Engineer: Stearns-Roger**
**Denver, Colorado**

**General Contractor:**
**Unit 1: National Industrial Constructors, Inc.**
**Dallas, Texas**
**Unit 2: Austin Power, Inc.**
**Dallas, Texas**



▲ *When Unit 1 of the Gerald Gentleman Station entered service in April 1979, it became Nebraska's largest fossil-fueled generating facility. Work on Unit 2 began June 1977, with completion in 1981. The rated generating capacity of each unit is 650,000 kilowatts. With both units in service, Gerald Gentleman is the largest power station in Nebraska.*

## Unit 1 Compared to Unit 2

Unit 1 was a more extensive project since it included coal handling, ash handling, precipitator, service and office structures that serve the entire station.

The sizes of the boiler building and the turbine building for the two units are identical,but the tons of structural steel are slightly different because the boiler and turbine equipment were purchased from different manufacturers. In round numbers, the steelwork in the boiler and turbine buildings of each unit can be rated at 11,300 tons.

## A Unique Opportunity to Study Direct Tension Indicators

The high-strength bolts on Unit 1 were inspected by the torque-wrench method. Direct Tension Indicators were used on Unit 2. This case history covers the experience on the comparable portions of the two units.

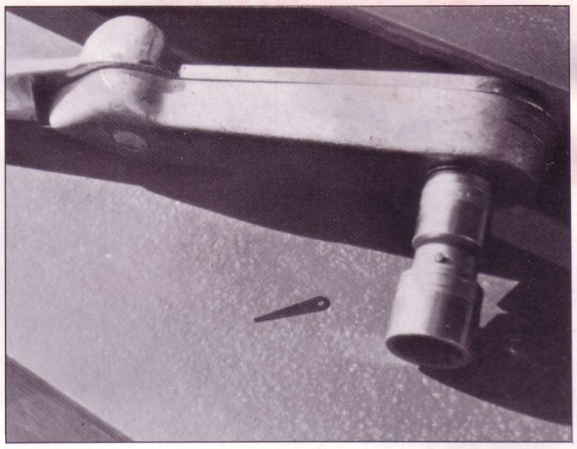
## INSTALLING BOLTS WITH DIRECT TENSION INDICATORS ON UN

*Bolt installation began on the ground, where bolts of proper length and quantity were a assembly included a Direct Tension Indicator – used under the bolt head – and a harde Bolts were tightened by a two-man crew. One man observed the Direct Tension Indicat*

### Owner's Construction Management on Unit 2

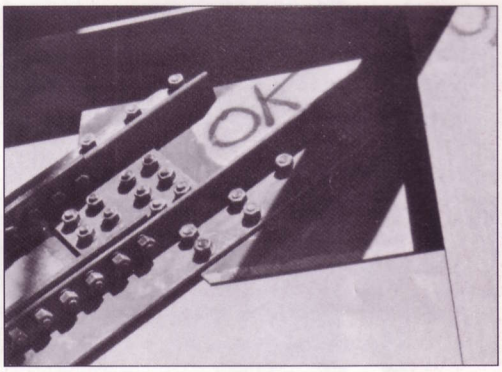
Jim Atwood, the Civil Construction Coordinator for NPPD, was most involved with the day-to-day work at the site. His enthusiasm for Direct Tension Indicators is based more on the proven integrity of the bolted joints than on cost savings. As an example: prior to the installation of the massive steam drum, Jim checked 100% of the bolts in the Unit 2 boiler building. He believed this was essential because some members had been removed and replaced to make way for other erection work. This checkup took only 2 1/2 days – well worth the resulting confidence and peace of mind.

### INSPECTION METHODS



*Bolts tightened without Direct Tension Indicators may be inspected with a torque wrench (photo does not show the entire length of the handle). Bolts with Direct Tension Indicators are inspected visually and with a small feeler gage. When the torque wrench is used, standard practice requires inspection of 10% of the bolts (or a minimum of two bolts) in each connection. It is difficult to maintain the accuracy of this method because it relies on the torque-tension relationship. Also, one should follow the requirements for calibrating the torque wrench. When Direct Tension Indicators are used, an experienced inspector can see that all the bolts have been properly installed. Use of the feeler gage can quickly verify that the bolts have been tightened to the specified tension.*

### INSPECTING BOLTS ON UNIT 2




*The quality control inspector for the general contractor visually checked all bolts. Questionable gaps were checked with a feeler gage. It's reassuring to walk through a structure and see a big OK, which shows that all bolts have been properly tightened and have passed inspection.*

### IT 2

*sembled for the connections. Each ed flat washer – used under the nut. rs under the bolt head, the other tightened the nut. When the gap between the Direct Tension Indicator and the underside of the bolt head was less than 15 mils (0.015 in.), the observer signalled the man on the wrench. Experienced workmen can readily judge the gap by eye, then check one or two with a feeler gage before leaving the connection. When wrench capacity, air pressure and bolt conditions ore satisfactory, proper bolt tension – as shown by the compressed gap – can be reached in 10 seconds or less.*

### COST FACTORS

**When comparing the costs for the bolt tightening methods on Units 1 and 2, these factors should be considered:**

1. **Bolt installation**
2. **Inspection**
3. **Purchase of Direct Tension Indicators**

**There are no figures for comparing bolt installation costs. Adding an extra item – the Direct Tension Indicator – to each bolt-nut-hardened flat washer assembly on the ground is a negligible factor. The same is true for handling the extra item during work at the connection. "Call-backs" to re-tighten bolts should definitely be reduced when using Direct Tension Indicators, because the iron-workers can easily check their work. The reduced costs for rework should greatly exceed the extra cost of handling Direct Tension Indicators, but since these factors cannot be measured, they are not included in the cost comparison.**

**The cost if inspection is a significant comparison, and figures are available. On Unit 2, inspection was handled by the contractor's quality-control man as part of his duties. There were no extra billings for this inspection. On Unit 1, torque-wrench inspection was performed by a test-laboratory inspector, with the assistance of iron-workers supplied by the general contractor. Both costs were billed to the owners. They report that the Unit 1 inspection costs for the boiler and turbine buildings totalled $183,500.**

**The cost of Direct Tension Indicators for the boiler and turbine buildings of Unit 2 are estimated at $30,000.**

**Subtracting the cost of Direct Tension Indicators from the savings on inspection, the net savings is slightly over $150,000. On a project costing over 340 million dollars, $150,000 is not going to "make or break" the job. But any saving is nice to have, and it proves our long-standing contention:**

**Direct Tension Indicators save far more money than they cost, and the contractor and the owner can take the peace of mind and the confidence as a free bonus.**

# A PRIMER on Direct Tension Indicators

*The Direct Tension Indicator is a hardened round washer with protrusions pressed out of the flat surface. It is a simple and accurate system for tightening and inspecting high-strength bolts.*

The Direct Tension Indicator is placed on a bolt with the protrusions bearing against a hardened surface – either the underside of the bolt head, or a hardened flat washer. **Figure 1** shows one of the most used assemblies: the Direct Tension Indicator under the bolt head, with the nut turned by the wrench.

Note the gap before tightening.

When the bolt and nut are tightened, as shown in **Figure 2**, the clamping force partially flattens the protrusions and reduced the gap. When the gap is closed to the required dimension (0.015 in.), the bolt and nut are properly tightened.

**Figure 3** shows two other methods to position the Direct Tension Indicator. In both these assemblies, the Direct Tension Indicator is under the turned element, i.e. the element of the assembly that is turned by the wrench. Note that a hardened flat washer must be used between the Direct Tension Indicator and the turned element. The required gap dimension in these assemblies is 0.005 in.

J&M Turner's Direct Tension Indicator is patented.

**NOTE: The Direct Tension Indicator is a precision-made device and should never receive any treatment after leaving our plant. Also, Direct Tension Indicators should not be reused.**

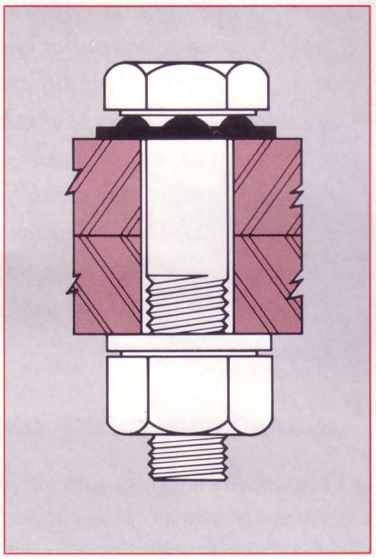


**FIGURE 1**

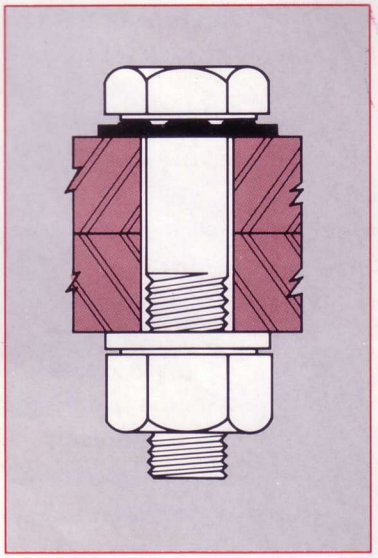


**FIGURE 2**

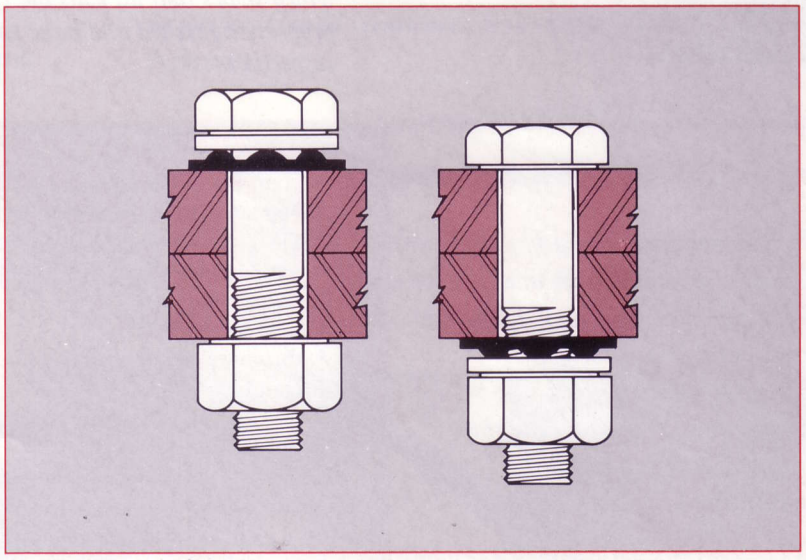


**FIGURE 3**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