SOCIETY OF PETROLEUM ENGINEERS OF AIME
6200 North Central Expressway
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PAPER NUMBER SPE 2902

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Skid Mounting an 1100 Horsepower Turbine Compressor Station

By

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ABSTRACT

Skid mounting compressor stations for portability will result in a minimum amount of wasted material and additional costs should the relocation of this station become necessary. Mountain Fuel Supply Company has recently skid mounted a remote control, completely automated 1100 horsepower turbine compressor station and installed it at a remote location south of Vernal, Utah.

The turbine compressor unit, piping, automatic valves, regulators and the unit controller are mounted inside of a building as one integral unit on a single skid; while the plant generators, boiler and station controller are mounted inside of another building on a second skid; and the microwave system and building are mounted on a third skid.

The yard piping and metering are the only part of this station which are not portable. Each of the three skids can be wenched onto a flatbed truck and moved to a new location with relative ease with only a minor amount of interconnecting piping and wiring necessary to complete the relocation.

References and illustrations at end of paper.

INTRODUCTION

Skid mounting equipment for portability has become increasingly popular with industry in recent years. The obvious advantage for making anything portable is in the cost savings when and if the particular piece of equipment should ever be moved. An additional advantage is in being able to do most of the fabrication under ideal conditions in a machine shop rather than at some distant location.

With these factors in mind, Mountain Fuel Supply Company has skid mounted a completely automated, remote control, 1100 horsepower turbine compressor station along with all of the necessary auxiliary equipment and have installed it at a remote location south of Vernal, Utah and east of Bonanza, Utah.

FUNCTION AND CONTROL

This compressor station was installed for the purpose of maintaining a 500 psig contract pressure at Bonanza, Utah, the beginning of our southern pipeline going into Orem, Utah. At the plant location, two additional laterals were tied into the system and the piping arranged so that this additional gas could be put into either the suction or discharge of the compressor station but would normally be into the discharge side. Variations in flow rates from these sources and other downstream sources cause the discharge pressure to range between 525 and 660 psig.

Based on these conditions, the compressor output was placed on a suction pressure controller sending 3 to 15 psi signals to the turbine governor. In addition, since it would be possible to put the compressor into surge if the flow rate from Bonanza **was** sufficiently reduced for any reason, it was decided to install a surge control system. Flame and gas detectors were installed in both the auxiliary building and compressor building along with a station emergency shut down system.

The surge control system consists of a second by-pass system with a long loop connecting between the unit discharge inside of the compressor building to a point on the plant suction lead upstream of the plant suction scrubber. A regulator, block valve and check valve are located on this line inside of the compressor building. A system of pneumatic instruments monitor the flow rate and compression ratio and computes the operating point in relation to the surge line. A signal is then sent to the surge control regulator to by-pass gas should the turbine be in danger of going into surge.

A 70 per cent speed switch was installed in the turbine instead of the normal 90 per cent speed switch to enable the turbine to be slowed to 135 horsepower without starting its stop sequence. Also, a low limit relay was installed on the 3 to 15 psi signal to the turbine governor to limit this signal to approximately 6 psi and prevent the stop sequence from starting because of a low output signal from the suction pressure controller. This prevents the by-pass valve from opening and closing as the stop sequence is started and then interrupted when the output of the controller changes. As an additional control on the suction pressure if the horsepower requirement should be below 135 horsepower, the suction pressure controller output signal was also piped to the surge control regulator after first going through an amplifying relay to multiply the signal by 4, a biasing relay to subtract 9 psi from the signal, and then to a low selector relay along with the surge control output. The lower of the two signals determines the surge control regulator opening.

With this system it is possible, when having extremely low horsepower requirements, to back off on the turbine power to the 6 psi limit and at that point to start by-passing gas through the surge control regulator so as not to lower the suction pressure more than the desired set point. This system gives the surge control regulator a dual function, mainly to keep the turbine out of surge; but secondly to help maintain a constant suction pressure.

If the turbine should be moved to another location, the surge control instruments would not have to be reset unless the turbine compressor was restaged. Also, the suction pressure controller could very easily be switched to discharge pressure control if necessary.

With the control system largely automatic as explained, the only control operated remotely from Rock Springs, Wyoming, is the ON-OFF switch. In addition, the following station status signals can be observed in Rock Springs.

1. Emergency shut down
2. General plant alarm
3. Illegal entry
4. AC power failure
5. Plant start verification
6. Plant on line
7. Plant suction pressure
8. Plant discharge pressure
9. Flow differential
10. Local control

Since the plant suction pressure remains relatively constant, it was decided that any adjustment in this could be made manually at the plant location. Also, all alarms must be manually cleared at the station after the cause of the malfunction has been determined.

DESCRIPTION

The compressor station is broken up into three separate skids with only the interconnecting piping and wiring and the station piping and metering not being skid mounted. The turbine compressor package along with all necessary equipment, wiring, and controls are mounted inside of one building on a single skid as one integral unit; while the plant auxiliary equipment and controls are mounted inside of another building on a second skid; and the microwave system and building are on a third skid.

The main compressor skid is made up of three 16-inch 50 lb. per foot I-beams, 36 feet long, set 3 feet apart. These main beams are connected together by a combination of 8-inch and 15-inch beams and with outriggers extending 3 feet on each side, which are made of split 8-inch beams, to support the building. The compressor unit, which was selected for this station, is the 1100 horsepower gas turbin compressor package which is in itself a skid mounted unit setting on a three point suspension. The three supporting pads on the turbin skid were positioned directly above the main support beams of the large skid so as to provide maximum support. The compressor building is a 28' x 12' x 8' insulated steel building which proved to be large enough to house the turbine and other equipment. Included inside of the compressor building is the main gas piping consisting of the valves, valve operators, and the orifice fitting for the surge control system; the surge control regulator and instruments; the fuel gas system consisting of the meter run and meter, the stop tank, the regulator and by-pass valve; the emergency shut down system consisting of a drying pot, regulators and valves; and miscellaneous equipment such as hoist, walkways, unit heaters and gas and flame detectors.

The auxiliary skid is made from three 10-inch I-beams, 24 feet long, with the necessary connecting beams and outriggers to support a 20' x 12' x 8' insulated steel building. Inside of the auxiliary building is included two 15 KW generator sets and a 240,000 Btu boiler in one section and the station controller, annunciator panel, standby batteries, battery chargers, inverter and gas detector panel in a second section.

The microwave building is an insulated fiberglass type with independent heating and air conditioning and containing the necessary microwave gear for transmitting the remote control signals to Rock Springs, Wyoming, 108 miles from the station.

The turbine building is spaced 100 feet from the nearest other building and is interconnected to the other buildings with the conduit and wiring and piping set on piers above ground.

SKID DESIGN

The basic design of larger skids used by Mountain Fuel follows a pattern which we have found to work quite well. The main support comes from three main beams running lengthwise, located close enough together so that they will pass between the guide pins at the ends of the tail roll of the truck trailer. These main beams are connected together with slightly smaller cross beams so that the cross beams are not as low as the sliding surfaces of the main beams. This will lessen the chances of damage to trailer surfaces when the skid is pulled onto or off of the trailer. Any additional width is provided for by outriggers extending outward, which are also made from beams smaller than the main beams. At the ends of the three main beams, the end roll is located low with just enough clearance provided for the winch cable to pass underneath without being pinned. Having the end roll low in this manner will keep the ends of the main beams from catching on the tail roll of the trailer and causing undue resistance when pulling the skid onto the trailer.

In making the selection for the size of beams to be used for the three main beams of the skid, it was assumed that the stresses would be distributed evenly between all three beams. After determining the total weight to be supported on the skid, a preliminary beam size was selected by assuming the actual stress and deflection would be less than if the total load were concentrated in the center of the skid and more than if the total load were distributed evenly over the entire skid length. After the beam size was selected, a more accurate determination of the deflection and stress was made with the various concentrated and distributed loads located as accurately as possible to their tentative locations.

COSTS

Since all compressor plants vary greatly in station piping and other requirements, only the costs directly involved in the skids themselves will be mentioned at this time. The following costs are for all material located on the skids with the labor, equipment and payroll overhead needed for their installation.

Main Compressor Skid		
Engineering and drafting		$ 6,450.00
Labor		19,870.00
Equipment		2,913.00
Material		
Turbine and accessories	$120,758.00	
Other material	31,390.00	
Total material		152,148.00
Total cost		$181,381.00

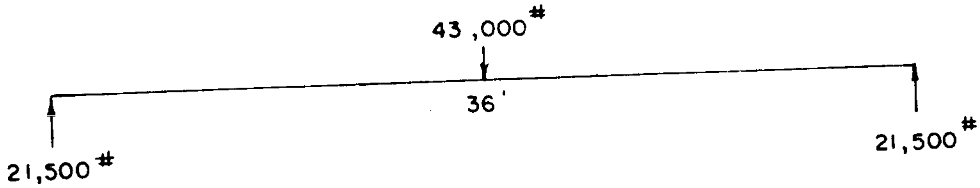
Auxiliary Skid Costs

Engineering and drafting	$ 3,220.00
Labor	6,585.00
Equipment	712.00
Material	15,133.00
Total cost	$25,650.00

If the station should ever be moved, these costs would be almost totally salvaged since the units would remain essentially unchanged. Additional costs would be acquired for reconnecting the heating and fuel gas piping and the plant wiring between the buildings. Also, the plant piping and other necessary piping and skid piers would have to be installed.

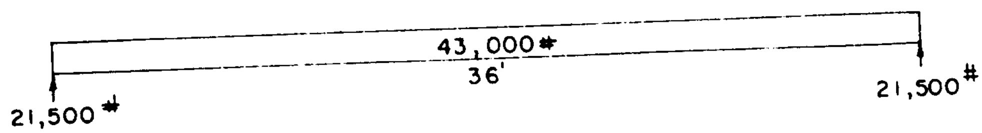
CONCLUSION

During the first winter of operation, only minor operating problems were encountered. It is generally felt that installing a station in this manner was a success and did not result in any unforeseen or difficult operating conditions. Mountain Fuel is presently in the process of skid mounting a second unit for installation on our northern system and any additional units will probably be skid mounted also.



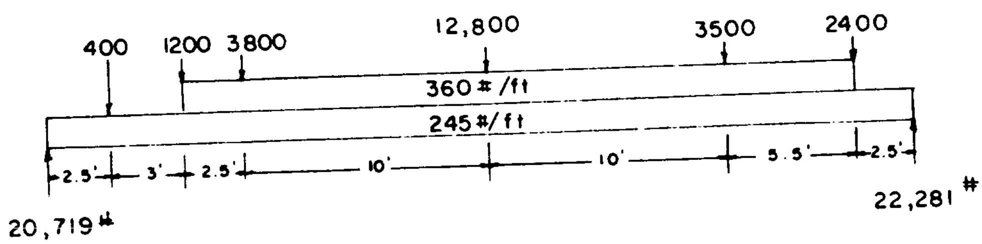
$$y = -\frac{PL^3}{48EI} = -1.22 \text{ Inches}$$

$$S = \frac{M}{I/c} = 19{,}180 \text{ psi}$$



$$y = -\frac{5WL^3}{384EI} = -.77 \text{ inches}$$

$$S = \frac{M}{I/c} = 9590 \text{ psi}$$



$$EI\frac{d^2y}{dx^2} = 22{,}281(X) - 2400(X-2.5) - 3500(X-8) - 12{,}800(X-18)$$
$$- 3800(X-28) - 1200(X-30.5) - 400(X-33.5) - 245(X)\frac{(X)}{2}$$
$$- \left[360(X-2.5)\frac{(X-2.5)}{2} - 360(X-30.5)\frac{(X-30.5)}{2}\right]$$

$$y = -88 \text{ Inches}$$

Moment is Maximum where $X = 18$

$$M_{18} = 20{,}719(X) - 400(X-2.5) - 1200(X-5.5) - 3800(X-8)$$
$$- \frac{245}{2}(X)^2 - \frac{360}{2}(X-5.5)^2$$

$$M = 245{,}900 \text{ ft LB}$$

$$S = \frac{M}{I/c} = 12{,}190 \text{ psi}$$

Fig. 1 - Calculations.

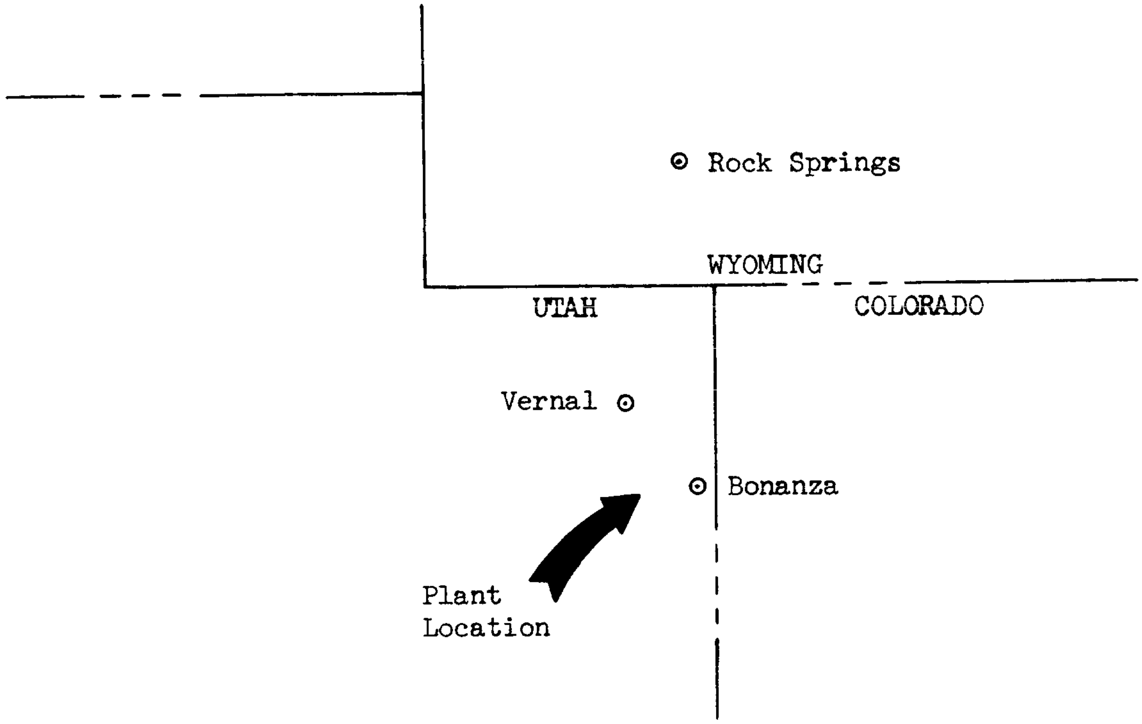
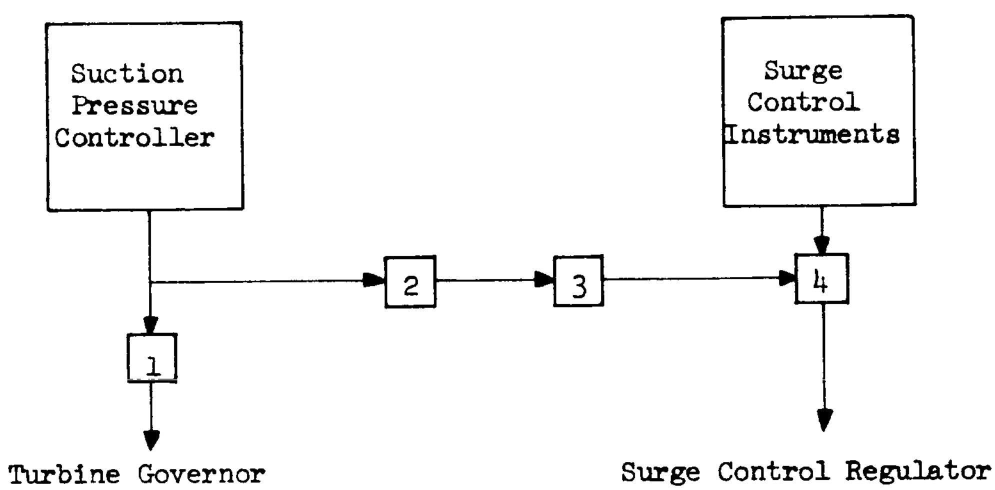


Figure 1
Location Map



1. Low limit relay - limits governor signal to 6 psi.
2. Amplifying relay - multiplies signal by 4.
3. Biasing relay - subtracts 9 psi from signal.
4. Low selector relay - selects lower signal to surge control regulator.

Fig. 2 - Station control system.

Fig. 3 - Inside of compressor building - valves, surge control regulator, ESD panel.

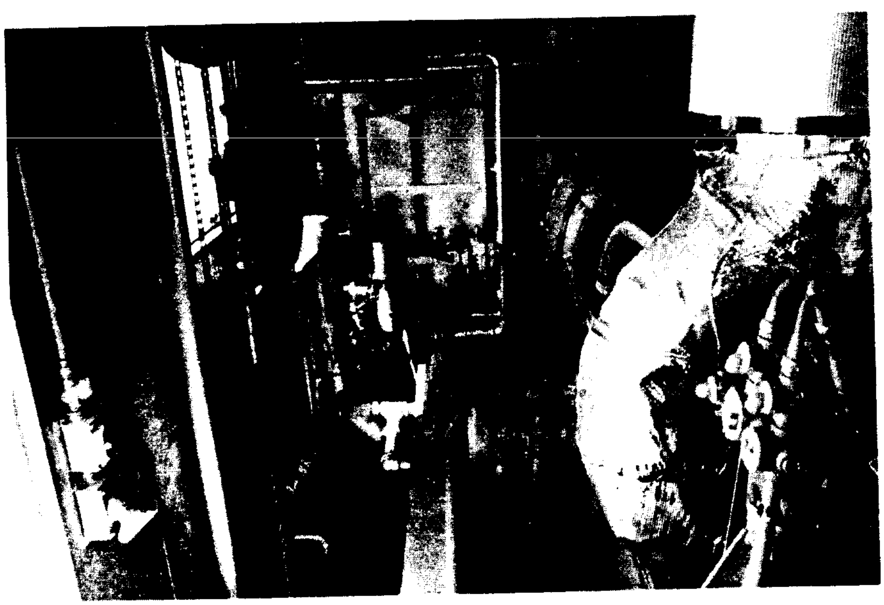


Fig. 4 - Inside of compressor building - fuel gas system in corner.

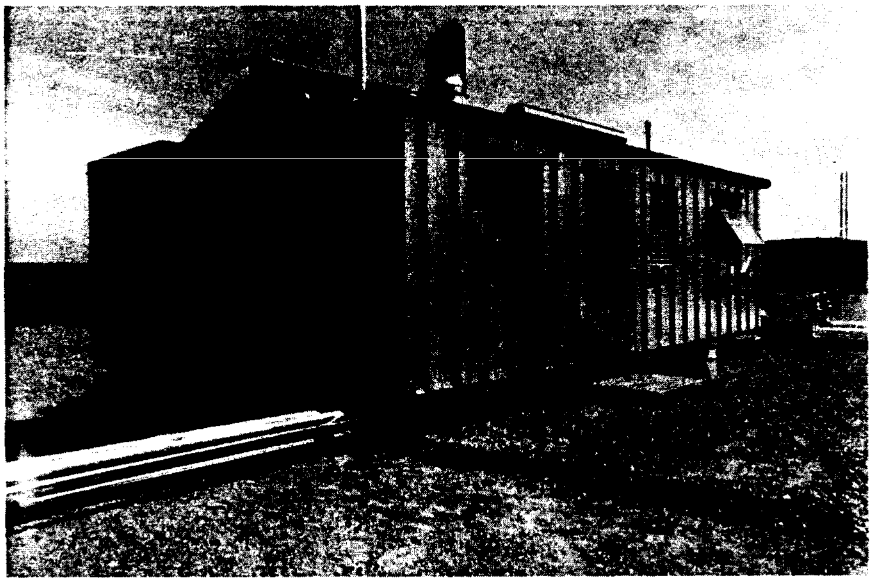


Fig. 5 - Turbine compressor building.

Fig. 6 - Auxiliary equipment building.