CONDENSER LOAD ON STEAM TURBINES

By Scott MacFarlane

For a turbine to be considered condensing, the exhaust pressure of the steam must be less than atmospheric. Condensing steam turbines operate with greater pressure drops throughout the turbine which results in large power output. These operating conditions create additional loads on the steam turbine that vary based on the exhaust nozzle size. Figure 1 shows the relationship between the turbine exhaust nozzle size and compression force between the turbine exhaust and condenser.

Due to these forces and the event of the turbine operating non-condensing, there are two typical configurations for mating the components. The first configuration has the condenser being rigidly fastened to the exhaust nozzle as shown in Figure 2. In this arrangement the "squeezing" load on the components is no longer the issue. The issues becomes supporting the condenser's over hung weight or the possibility of the turbine operating non-condensing if the condenser is rigidly fixed to the baseplate. If the turbine operates non-condensing and the condenser is rigidly fixed, the condenser would grow upwards from the hotter exhaust temperatures and would try to move the turbine upwards. This would ultimately lead to one of the components failing. A remedy to this issue is the implementation of calibrated springs under the condenser feet. The springs would be capable of handling the condenser weight during normal operation and would minimize the upward thrust of the condenser from the turbine operating non-condensing. The second configuration utilizes as expansion joint between the turbine and condenser. Figure 3 shows a typical expansion joint configuration. Here the forces

Turbine Exhaust Nozzle Size		Compression Force between Turbine & Condenser (Condensing Operation)			Tension Force between Turbine & Condenser (Non-Condensing Operation)
Diameter (Inches)	Area (Sq. Inches)	26" Hg Vacuum (lbs-f)	28" Hg Vacuum (lbs-f)	29" Hg Vacuum (lbs-f)	10 PSIG Back Pressure (lbs-f)
30	706.9	9,027	9,719	10,066	7,069
36	1,017.9	12,998	13,996	14,495	10,179
42	1,385.4	17,692	19,050	19,729	13,854
48	1,809.6	23,108	24,881	25,768	18,096
60	2,827.4	36,106	38,877	40,263	28,274
72	4,071.5	51,993	55,983	57,978	40,715
84	5,541.8	70,768	76,199	78,915	55,418
96	7,238.2	92,432	99,526	103,072	72,382

Figure 1

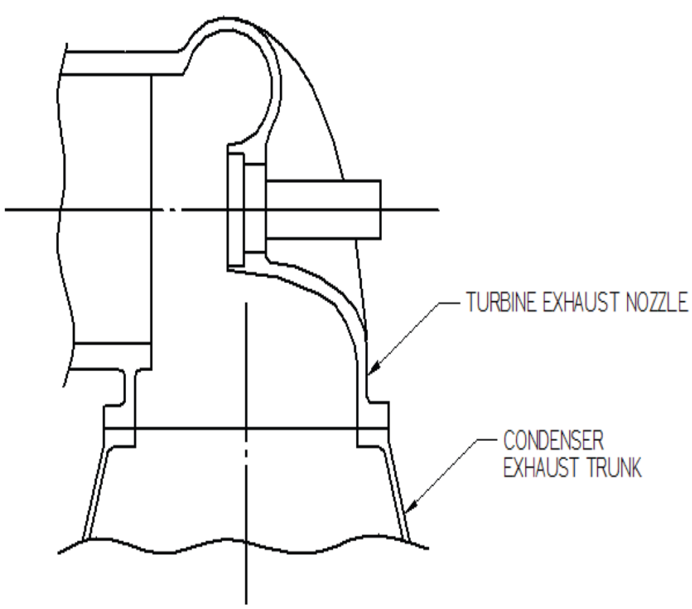

Figure 2

trying to compress the components during normal operations or separate them during non-condensing operation become the issue. It is important that the expansion joint be flexible enough to withstand the constant changes in operating conditions.

The expansion joint configuration is the simpler option but both come with their own set of pros and cons. The expansion joint is more susceptible to fatigue cracking and erosion from the steam. The benefit of the direct bolted joint configuration is less possibility of air leaking in and deteriorating vacuum and performance. However, the springs in this configuration can cause immense twisting moments from the changing temperatures and pressures of the circulating condenser water. Both configurations should be considered when installing your condensing turbine.

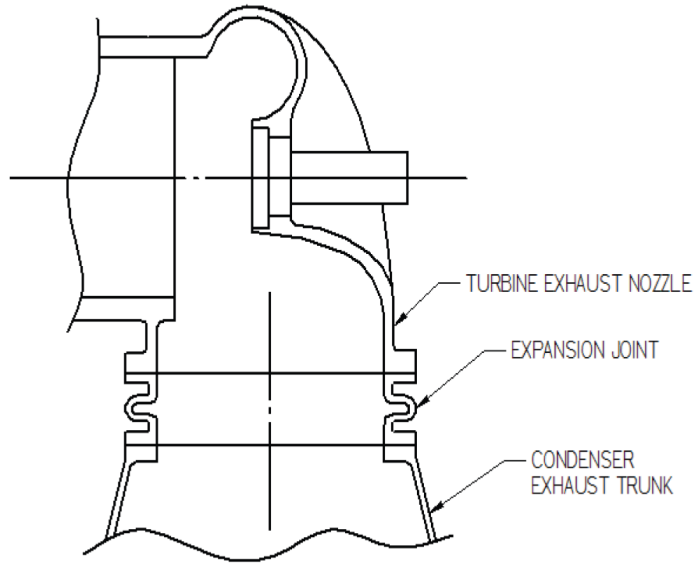

Figure 3

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