

T H E S I S

TEST OF A 360 H.P. INGERSOLL-RAND AIR COMPRESSOR
AT THE SOUTHERN RAILWAY SHOPS.

For the Degree of

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING.

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Under

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This is an Ingersoll-Rand two stage compressor, with balance wheel and twin engines. The engines are equipped with slide valves having riding cut-offs with fixed eccentrics, so that all the events of the stroke are fixed, the regulation being effected by a plain throttling governor. This governor is air controlled and set to keep a pressure in the air tank of from 85 to 90 lbs. To guard against excessive speeds at low air pressures the governor is further provided with a belt driven from the shaft as an ordinary ball governor. This limits the speed to about 100 R.P.M.

Variation of load affects the distribution of steam in the cylinders, but slightly as is shown by the similarity of cards taken at widely differing loads. The speed was the only factor which changed appreciably to meet varying loads.

The compressor exhausts into a 12 inch main leading from the power house to the boiler room, thence through an open heater from which it rises through the roof and exhausts to atmosphere. The exciter engines and the vacuum pump of the turbine condenser also exhaust into this main. For the purpose of the test the exhaust lines from the exciter engine which was used during the test and the vacuum pump, were disconnected from the large exhaust main, the exhaust from these auxiliaries being turned just outside the power room, and the pipes connected to the main blanked. At a point between the power house boiler room this main was broken, a section taken out and a short section of pipe containing a six inch tee and with one end blanked was put in place of the section removed. From this tee a six inch pipe led to a closed feed water heater which

served as a condenser. As this heater was used only to condense the steam at atmospheric pressure the cooling water was raised to a high temperature and used for boiler feed water.

During the test observations were taken every half hour, on the light and medium loads, but on the full load run of one hour and 10 minutes, cards were taken every five minutes and other observations as often as practicable. The quality of steam was taken at a point close to one of the turbines, there being no way of connecting the calorimeter to the steam pipe near the compressor. Four indicators were used. In the tables are some diagram dimensions. There are only approximate but may be considered to represent fairly well the average.

There were three well defined periods of load, and the steam consumption and efficiency have been worked out for each load; the light load is the night load; the medium load is the ordinary day load and the full load was put on for the purpose of the test, and carried for one hour and 10 minutes.

From the cards it appears that the left cylinder does from eight to twelve percent more work at all loads than the right cylinder. Cards from the air end indicate that there is from ten to fifteen percent more work to be done on the left side than on the right at light and medium loads, but at full load the conditions are reversed and there is more work to be done on the right side (1st stage) than on the left (2nd stage).

The rated H.P. of the compressor is 360 at 100 R.P.M. and compressing against 80 pounds.

DIMENSIONS.

Steam Cylinders.

Diameter of cylinders	22"
Diameter of piston rods	$3\frac{5}{8}"$
Area of cylinders, effective, head end sq.in.	369.8
Area of cylinders, effective crank end, sq.in.	369.8
Length of stroke	24"

Air Cylinders.

Right Cylinder, 1st stage.

Diameter cylinder	$34\frac{1}{4}"$
Diameter of piston rod	$3\frac{5}{8}"$
Diameter of tail rod	$10\frac{5}{8}"$
Area of piston (effective) head end sq.in.	836.8
Area of piston effective crank end sq.in.	916.67
Stroke.	24"
Piston displacement, head end cu.ft.	11.60
Piston displacement crank end cu.ft.	12.62

Left Cylinder, 2nd stage.

Diameter cylinder	$22\frac{1}{4}"$
Diameter piston rod	$3\frac{5}{8}"$
Diameter tail rod	$7\frac{1}{2}"$
Area of piston (effective) head end sq.in.	344.8
Area of piston effective crank end sq.in.	378.67
Stroke	24"

DIAGRAM DIMENSIONS.

Steam cards.

Cut off for stroke	50
Compression % stroke	3.5

Absolute pressure at cut off head end	74.3
Absolute pressure at cut off crank end	76.3
Absolute pressure at release head end	35
Absolute pressure at release crank end	35
Back pressure	16

CONDITIONS OF TEST.

Duration, hours, light load	4 1/3
Duration hours, medium load	6 1/2
Duration hours, full load	1 1/6
Speeds, light load	27
Speeds, medium load	48
Speeds, full load	88
% rated H.P. light load	29.1
% rated H.P. medium load	57
% rated H.P. full load	96
Steam pressure	136
Air pressure in tank	91.5
Air pressure in receiver	22
Barometer, in, Hg	29.09"
Back pressure on calorimeter	1.56"
Steam temperature, Fahr.	358.2
Temperature in calorimeter	275
Boiling temperature in calorimeter at atmos.	213
Superheat in calorimeter	62
Quality of steam %	98.4
% cut off steam cylinder	50

INDICATED WORK OF COMPRESSOR.

Steam Cylinders.

	Light load I.H.P.	Medium load I.H.P.	Full load I.H.P.
Right cylinder head end	24.25	44.50	79.00
Right cylinder crank end	25.50	46.25	81.50
Left cylinder head end	27.25	51.00	91.50
Left cylinder crank end	28.00	51.50	93.50
Right cylinder total	49.75	90.75	160.50
Left cylinder total	55.25	102.50	185.00
Total I.H.P. for both cylinders	105.00	193.25	345.50

Air Cylinders.

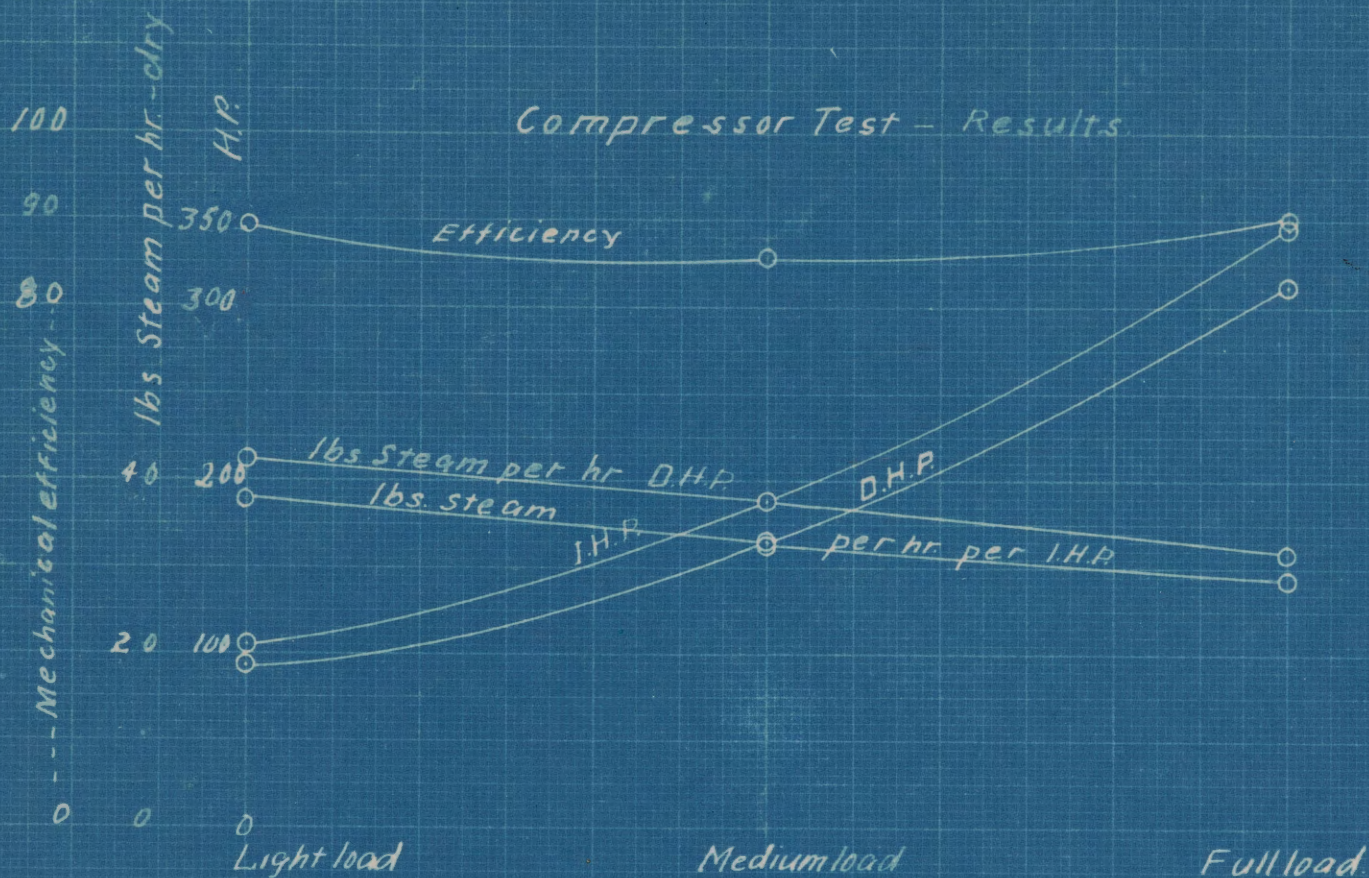
Right cylinder 1st stage hd.end	21.00	37.75	75.00
Right cylinder 1st stage ck.end	23.00	42.50	86.00
Total right cylinder	44.00	80.25	161.00
Left cylinder 2nd stage hd.end	23.50	42.20	72.00
Left cylinder 2nd stage ck.end	26.00	42.50	79.00
Total left cylinder	49.50	84.70	151.00
Total I.H.P. for both cyl.	93.50	164.95	312.00
Mechanical efficiency %	89.0	85.5	90.0
Thermodynamic efficiency %	6.5	6.5	6.5

Steam consumption.

Actual per hour lbs.	4038.1	6323.5	9843.1
Moisture in steam	1.6	1.6	1.6
Dry steam per hour	3963.5	6222.3	9685.0
Steam per I.H.P. actual	38.4	33	29.0
Dry steam per I.H.P.	37.8	32.5	28.6
Dry steam per D.H.P.	42.4	37.7	31.5

Period	Indicated Work. Horse powers.		Del. Work. I.H.P. of air cyl.		Total water consumption.
	St.cyl.	L.cyl.	1st stage	2nd stage	
9:30-10:00	97.5	113	85	99	3137
10 -10:30	97.2	112	87	98	3234
10:30-11:00	93	108	83.5	95	3542
11 -11:30	91	106	79.5	94	3583
11:30-12:00	88	100	75	88	3036
12 -12:30	61	71	52	61	2181
12:30-1:00	86	99	74	87	3228
1 - 1:30	86	97	74	84	3165
1:30-2:00	86	96	74.5	83	2888
2:00-2:30	92.5	101.5	82.5	89	3244
2:30-3:00	96	108.	89	93	3145
3:00-3:30	93.5	104.	87	92	3032
3:30-4:00	91	100	82.5	88	2948
4 -4:30	88.5	98	80	85.5	2921
4:30-5:05	52	56	48	53	2617
5:05-5:40	162	185	162	151	5882
5:40-6:15	161	186	161	151	5777
6:15-7:00	44	49	38	44	3280
7:00-7:30	45	50	39.5	44	1612
7:30-8:00	48	54.5	44.5	47	1651
8 -8:30	52	58.5	48	46.5	2047
8:30-9:00	53½	59	47	55	2146
9 -9:30	48	52	41	51	1951

Compressor Test - Results



Compressor Test - Log

Temp. Calorimeter Air.

