# Condenser Revamping

Specifically adapted for the modular renovation of steam surface condensers through complete replacement of the tube bundles, this program calculates the performance of the new unit and corresponding production gains for a one year period from turbine and cooling water pump characteristics.

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This program is intended for carrying out perform optimization studies of thermoelectric plant steam condenser tube bundles to facilitate bundle replacement in modular systems whereby existing tube bundles are exchanged for an alternative design with different geometric characteristics including tube type and quantity. So the program is designed to be used by equipement manufacturers who want to participate in the market of condenser revamping. But the program can also be of use to the thermoelectric plant owners since it can be used to carry out a performance analysis of condensers.

Modular revamping of condensers is a technique that has been employed for many years and was originally developed in response to the need to change the material of the tubes because of degradation and to avoid the denting phenomenon which can occur in the steam generators of nuclear systems containing condensers with copper alloy tubing.

The modular revamping of a condenser may call for use of a different tube material, tube diameter and tube quantity, making it necessary to perform a hydraulic study of the available pumping capacity. At the same time, the new tube bundle should be adapted to the characteristics of the bundle location in the shell of the condenser whilst aiming to improve the unit efficiency by increasing the installed heat transfer surface area.

With this program one can carry out this study as well as evaluate the efficiency of the unit during the course of its operating lifetime by means of the turbine and refrigeration system conditions.

Currently, the renovation of these condensers, due to the problems associated with the use of copper, is diminishing owing to the fact that new units already incorporate tubes of more resistant materials and have improved design efficiencies.

Nevertheless, the use of this program is not limited to revamping studies of this nature, but rather, the program can be used to study the performance of an existing condenser and then compare this with a hypothetical newly renovated condenser.

In the same way, if the condenser performance is decreasing, the program can be used to verify the loss of efficiency of the unit in relation to the performance of the condenser when it was installed.

The following section includes a description of the program, how to use it and how to interpret the calculated results.

Before starting the program the user should confirm that they possess the required geometry and process data, the latter of which should reflect the characteristics observed at the plant, specifically the cooling water pumping curve, the turbine efficiency curve in function of the condenser vacuum and the temperatures of the cooling water at the time of the evaluation.

After starting the program, the initial screen shows the Input Sheet where the required data, corresponding to the existing condenser, are specified by the user. There are three data that may be unfamiliar. Firstly, the level difference between the suction and propulsion of the pump. This information should be provided by the unit owner. Secondly, the maximum insertion dimensions for the new tube bundle. This information should be gleaned from plans of the existing condenser and its surroundings, with the aim of maximizing the installed heat transfer surface. Thirdly, the tube occupation coefficient, which is the relationship between the drilled area of the tubesheet for placement of the tubes and the total tubesheet area (width by height).

For new condensers, it is necessary to specify the following data:

- The specified inside diameter of the tubes for the first calculation should be similar to the inside diameter of the existing tubes and this can then be modified later depending on the desired result.
- The tube length will be, except in rare cases, the same as the existing length.
- The number of tube bundles will be, naturally, the same as the existing number.
- The tube occupation coefficient is fundamental, as this determines the final number of tubes. One should perform an advance study of this coefficient with relation to the dimensions of the new tubesheets bearing in mind that according to experience this coefficient is typically around 0.35 for low density bundles and 0.45 for very compact bundles but with an elevated risk of not complying with the available pressure drop in the body of the condenser.
- Exchange coefficients are according to H.E.I. (Heat Echange Institute).
- The rest of the data are self-explanatory except for the cleanliness coefficient which can be greater than 1 in simulation with materials other than titanium or stainless steel which are the materials considered by this program and those most commonly considered in modular revamping projects. This coefficient can also be employed to simulate the deterioration in performance of condensers.

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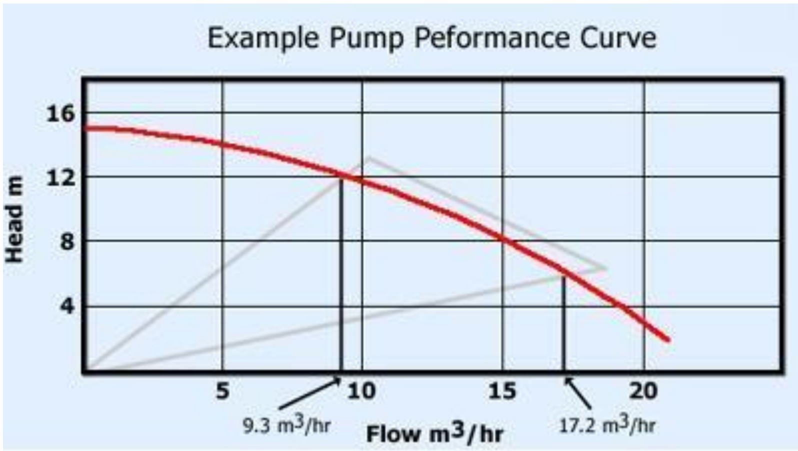
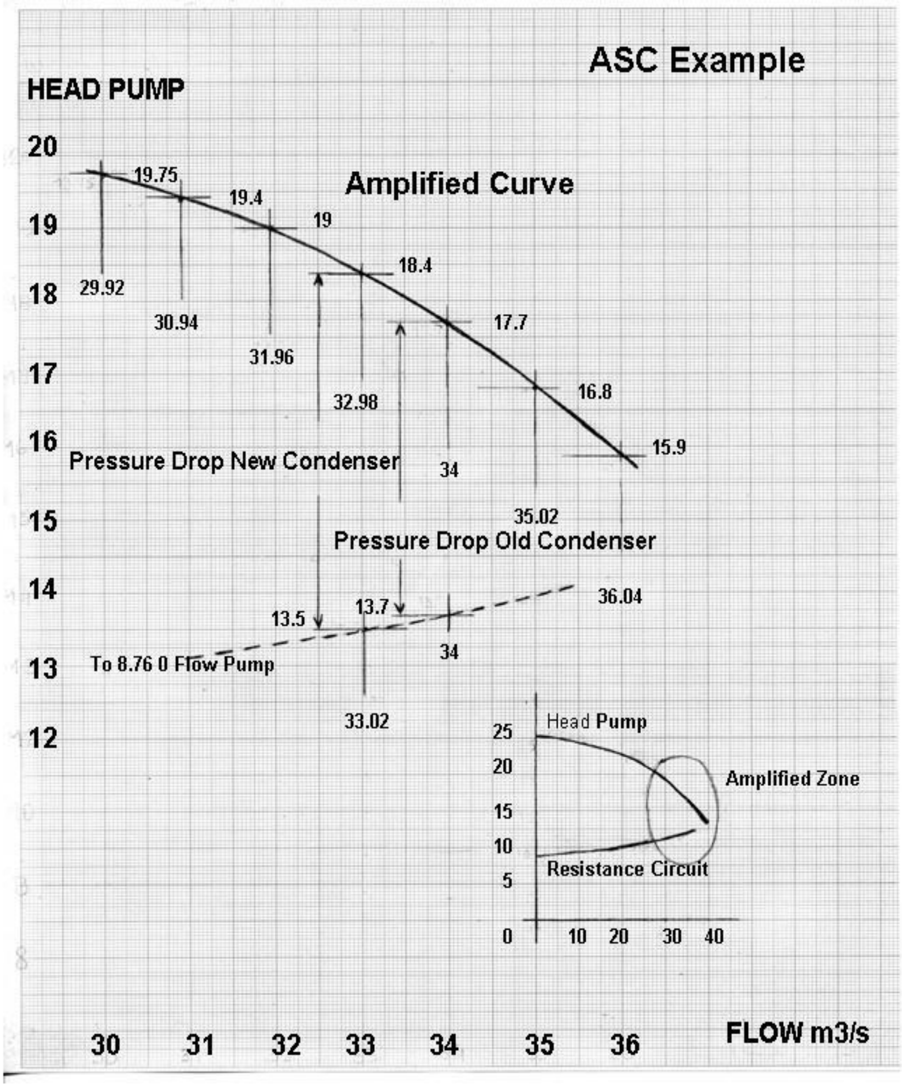
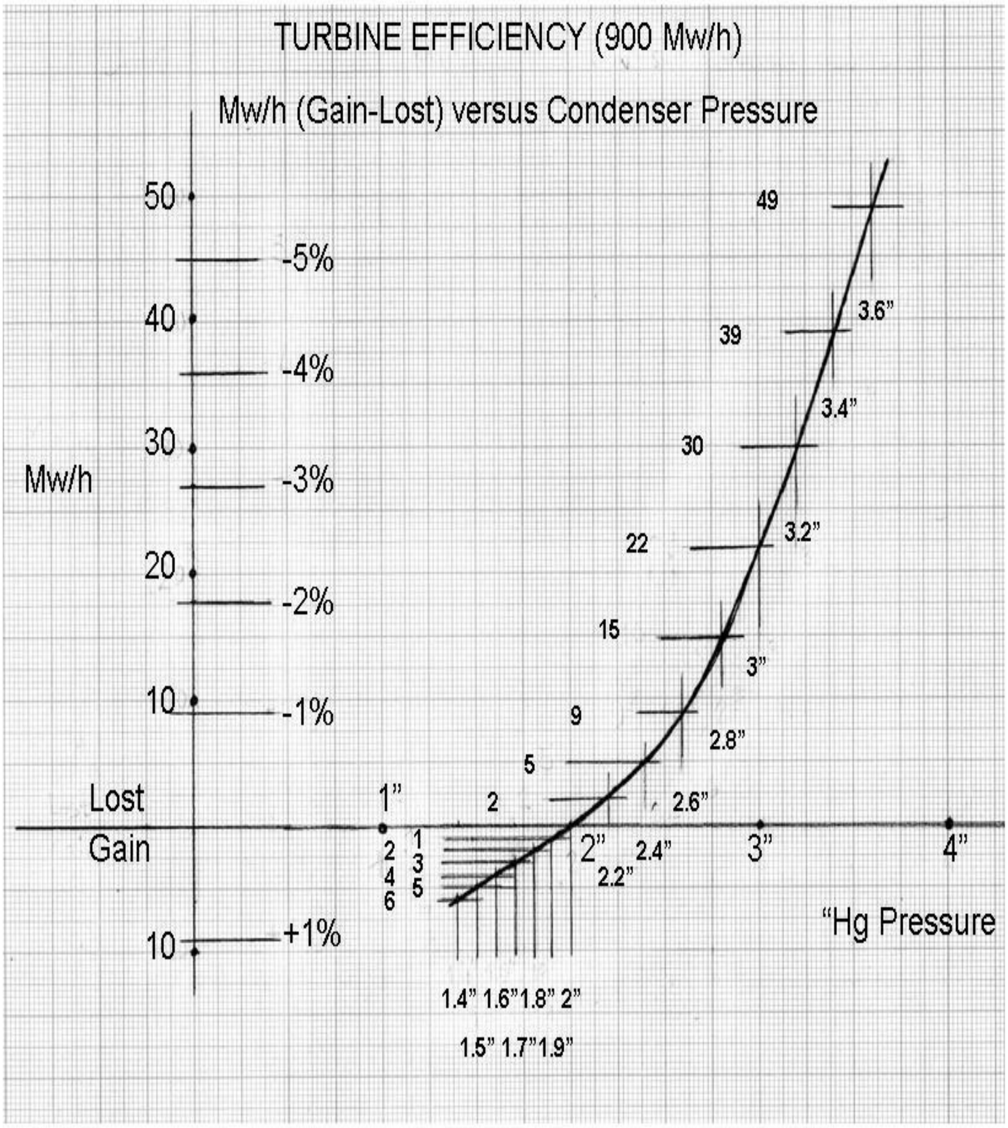


Example Pump Peformance Curve
Head m
16
12
8
4
5
10
15
20
9.3 m3/hr
Flow m3/hr
17.2 m3/hr



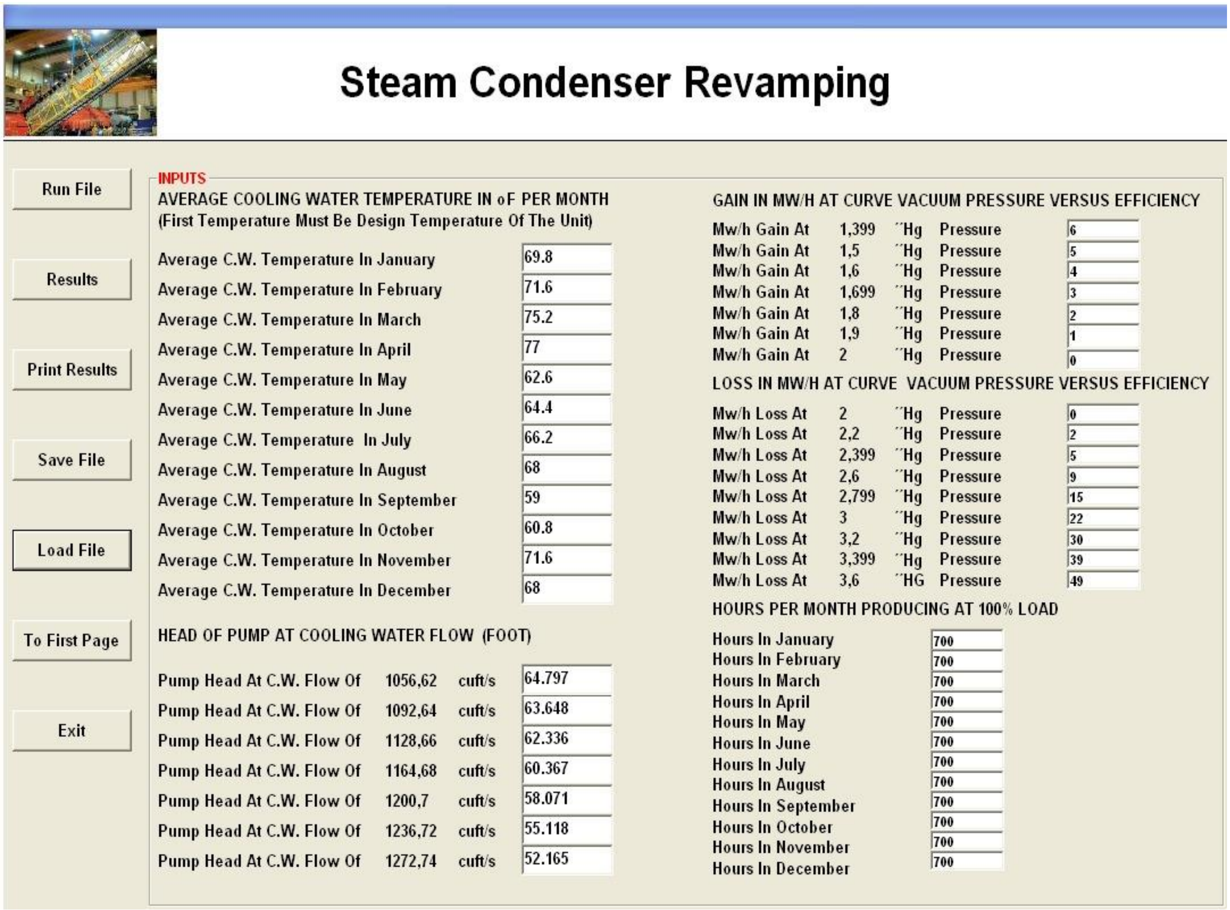
ASC Example
HEAD PUMP
20
19
18
17
16
15
14
13
12
Amplified Curve
19.75
19.4
19
18.4
17.7
16.8
15.9
29.92
30.94
31.96
32.98
34
35.02
36.04
Pressure Drop New Condenser
Pressure Drop Old Condenser
13.5
13.7
34
To 8.76 0 Flow Pump
33.02
Head Pump
25
20
15
10
5
0
Amplified Zone
Resistance Circuit
10
20
30
40
30
31
32
33
34
35
36
FLOW m3/s



TURBINE EFFICIENCY (900 Mw/h)
Mw/h (Gain-Lost) versus Condenser Pressure
50
40
30
20
10
10
Mw/h
-5%
-4%
-3%
-2%
-1%
+1%
Lost
Gain
1"
2"
3"
4"
"Hg Pressure
49
39
30
22
15
9
5
2
3.6"
3.4"
3.2"
3"
2.8"
2.6"
2.4"
2.2"
1
2
3
4
5
6
1.4" 1.6" 1.8" 2"
1.5" 1.7" 1.9"

# PROGRAM WINDOWS


## DATA ENTRY WINDOW 1/2




**DATA ENTRY WINDOW 2/2**

## Steam Condenser Revamping - Results 1/2

Job Name : PRUEBA ASC

TEMP = C.W.Temperature (oF)
COEFF = Exchange Coefficient (Btu/hoFft2)
INCRE = C.W.Increase Temperature (oF)
FLOW = Cooling Water Flow (cuft/s)
COND = Condensation Temperature (oF)
PRES = Condensation Pressure ('' Hg)
VELO = Tubes Velocity (ft/s)
DROP = Tube Side Pres.Drop (wftc)
MW = Gain or Loss (Mwh)

| TEMP | COEFF | INCRE | FLOW | VELO | DROP | COND | PRES | MWh |
|---|---|---|---|---|---|---|---|---|
| 69,8 | 567,1 | 23,77 | 1166,72 | 6,59 | 16,07 | 99,62 | 1,911 | 619,2 |
| 71,6 | 572,5 | 23,76 | 1167,33 | 6,6 | 16,02 | 101,3 | 2,009 | -71,8 |
| 75,2 | 582,1 | 23,73 | 1168,7 | 6,6 | 15,91 | 104,68 | 2,223 | -1671,4 |
| 77 | 586,3 | 23,72 | 1169,32 | 6,61 | 15,86 | 106,39 | 2,337 | -2866,9 |
| 62,6 | 539,9 | 23,83 | 1163,87 | 6,58 | 16,31 | 93,09 | 1,565 | 3035,9 |
| 64,4 | 547,6 | 23,82 | 1164,61 | 6,58 | 16,25 | 94,69 | 1,644 | 2478,6 |
| 66,2 | 554,7 | 23,8 | 1165,35 | 6,58 | 16,19 | 96,31 | 1,729 | 1889,8 |
| 68 | 561,1 | 23,79 | 1165,97 | 6,59 | 16,13 | 97,97 | 1,817 | 1267,3 |
| 59 | 522,7 | 23,87 | 1162,25 | 6,57 | 16,43 | 89,94 | 1,419 | 4059,6 |
| 60,8 | 531,6 | 23,85 | 1163,12 | 6,57 | 16,37 | 91,5 | 1,49 | 3562,7 |
| 71,6 | 572,5 | 23,76 | 1167,33 | 6,6 | 16,02 | 101,3 | 2,009 | -71,8 |
| 68 | 561,1 | 23,79 | 1165,97 | 6,59 | 16,13 | 97,97 | 1,817 | 1267,3 |

Gain or Loss (-) in Mwh 13499,1

Press For Results 2/2

**RESULTS SHEET 1/2**

## Steam Condeser Revamping - Data And Results 2/2

**Job Name :** PRUEBA ASC

### ■ Data For Existing Condenser

| | | |
|---|---|---|
| Total Heat Load | 6235,104 | Mbtu/h |
| Cooling Water Inlet Temperature | 69,8 | oF |
| Design Pressure | 2 | " Hg |
| Cooling Water Flow | 1200,7 | cuft/s |
| Pump Head Design Cooling Water Flow | 58,071 | ft |
| Total Number Of Tubes | 38590 | |
| Total Length Of Tubes | 56,004 | ft |
| Diameter Of Tubes | 1 | in |
| Normal Tubes Thickness | 0,04882 | in |
| Impact Tubes Thickness | 0,04882 | in |
| Air Cooling Zone Tubes Thickness | 0,04882 | in |
| Impact Tubes Percentage | 5 | % |
| Air Cooling Zone Tubes Percentage | 5 | % |
| Cooling Flow Passes | 1 | |
| Pump Level Differen.Discharge - Suction | 28,74 | ft |
| Cooling Water Type | Brackish Water | |

### ■ Data For Condenser Revamping

| | | |
|---|---|---|
| Height Of Tube Nest Inscrip.Tube Sheet | 133,386 | in |
| Width Of Tube Nest Inscrip.Tube Sheet | 146,378 | in |
| Tubes Diameter | 0,748 | in |
| Length Of Tubes | 56,004 | ft |
| Number Of Tubes Nest | 4 | |
| Drilled Surface Coeffic. In Tube Sheet | 0,38 | |
| Normal Tubes Thickness | 0,02756 | in |
| Impact Tubes Thickness | 0,02756 | in |
| Impact Tubes Percentage | 5 | % |
| Tubes Material | Titanium | |
| Cleanliness Factor | 0,9 | |

### ■ Results For Condenser Revamping

| | | |
|---|---|---|
| Cooling Water Flow | 1166,72 | cuft/s |
| Coolinw Water Increase Temperature | 23,77 | oF |
| Condensation Pressure | 1,91 | " Hg |
| Cooling Water Velocity In Tubes | 6,59 | ft/s |
| Number Of Tubes | 67536 | |
| Exchange Surface | 737634 | sqft |
| Tube Nest Pressure Drop | 16,07 | wftc |
| Exchange Coefficient | 567,1 | Btu/hoFft2 |

**RESULTS SHEET 2/2**