

# GENERAL INFORMATION ABOUT RETROFITTING OF AIR COOLER

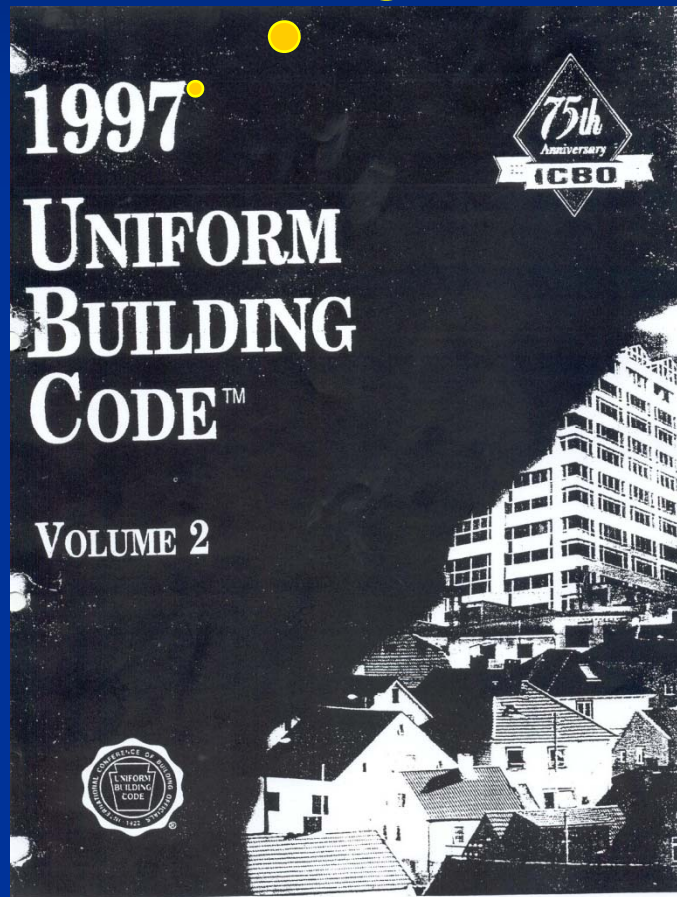
# CONTENTS :

- 1- DESIGN CODE AND STANDARD FOR AIR COOLER.
- 2- DIFFERENT TYPE OF AIR COOLER.
- 3- SAMPLE DATA SHEETS OF AIR COOLER.
- 4- DESIGN FLOWCHART OF AIR COOLER.
- 5- DIFFERENT TYPE OF RETROFITTING OF AIR COOLER.

# 1. DESIGN CODE AND STANDARD FOR AIR COOLER

**U.B.C.  
1997**

**API-661**



**Air-Cooled Heat Exchangers for  
General Refinery Services**

API STANDARD 661  
SECOND EDITION, JANUARY 1978  
REAFFIRMED, DECEMBER 1987

American Petroleum Institute  
1220 L Street, Northwest  
Washington, D.C. 20005



## AIR-COOLED HEAT EXCHANGERS FOR GENERAL REFINERY SERVICES

### SECTION 1—GENERAL

#### 1.1 Scope

**1.1.1** This standard covers the minimum requirements for design, materials, fabrication, inspection, testing, and preparation for shipment of **refinery process air-cooled heat exchangers**.

**1.1.2** The air-cooled heat exchanger shall be of the forced- or induced-draft type and shall include components as described in Figure 1 and any auxiliaries such as ladders and platforms.

#### 1.2 General

**1.2.1** The tube bundles shall conform to the requirements of **Section VIII, Division 1 of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code** and the supplemental requirements herein, regardless of whether code stamping is required.

**†1.2.2** When the exchanger is to contain lethal substances as indicated on the specification sheet, construction of pressure parts shall be in accordance with Paragraph UW-2(a), Section VIII, Division 1 of the ASME Code.

**\*1.2.3** The vendor shall comply with local rules and regulations that are specified by the purchaser.

Note: A bullet (\*) at the beginning of a paragraph indicates where a decision may be required of the purchaser which may not be obvious from the specification sheet (see checklist shown in Appendix B). A dagger (†) at the beginning of a paragraph indicates where an item or items are mentioned which appear on the air-cooled heat exchanger specification sheet (see Appendix E).

#### 1.3 Referenced Publications

The latest editions or revisions of the following standards, codes, or specifications shall, to the extent specified herein, form a part of this standard:

##### AGMA<sup>1</sup>

- |        |   |
|--------|---|
| 260.02 | <i>Design of Components - Enclosed Gear Drives - Bearings, Bolting, Keys and Shafting</i>                           |
| 420.04 | <i>Practice for Enclosed Speed Reducers or Increaseers Using Spur, Helical, Herringbone, and Spiral Bevel Gears</i> |

##### AISC<sup>2</sup>

###### *Manual of Steel Construction*

*Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings*  
*Code of Standard Practice for Steel Buildings and Bridges*  
*Specification for Structural Joints Using ASTM A 325 or A 490 Bolts*

##### ANSI<sup>3</sup>

- |           |  |
|-----------|--|
| A58.1     | <i>Building Code Requirements for Minimum Design Loads in Buildings and Other Structures</i> |
| B1.1      | <i>Unified Inch Screw Threads (UN and UNR Thread Form)</i>                                   |
| B2.1      | <i>Pipe Threads (Except Dryseal)</i>   |
| B3.15     | <i>Load Ratings and Fatigue Life for Ball Bearings (AFBMA Standard 9)</i>                    |
| B3.16     | <i>Load Ratings and Fatigue Life for Roller Bearings (AFBMA Standard 11)</i>                 |
| B4.1      | <i>Preferred Limits and Fits for Cylindrical Parts</i>                                       |
| B16.5     | <i>Steel Pipe Flanges, Flanged Valves, and Fittings</i>                                      |
| B16.11    | <i>Forged Steel Fittings, Socket-Welding and Threaded</i>                                    |
| B17c-1927 | <i>(R1947) Codes for the Design of Transmission Shafting<sup>4</sup></i>                     |
| S1.4      | <i>Specification for Sound Level Meters</i>  |
| S1.11     | <i>Specifications for Octave, Half-Octave, and Third-Octave Band Filter Sets</i>             |

##### API

- |      |  |
|------|--|
| 500A | <i>Recommended Practice for Classification of Areas for Electrical Installations in Petroleum Refineries</i> |
|------|--|

<sup>1</sup>American Gear Manufacturers Association, 1901 N. Fort Meyer Drive, Arlington, Virginia 22209

<sup>2</sup>American Institute for Steel Construction, 101 Park Avenue, New York, New York 10017

<sup>3</sup>American National Standards Institute, 1430 Broadway, New York, New York 10018

<sup>4</sup>Withdrawn December 1954; available from ANSI

## 2- DIFFERENT TYPE OF AIR COOLER

# FORCED & INDUCED DRAFTING IN AIR COOLERS

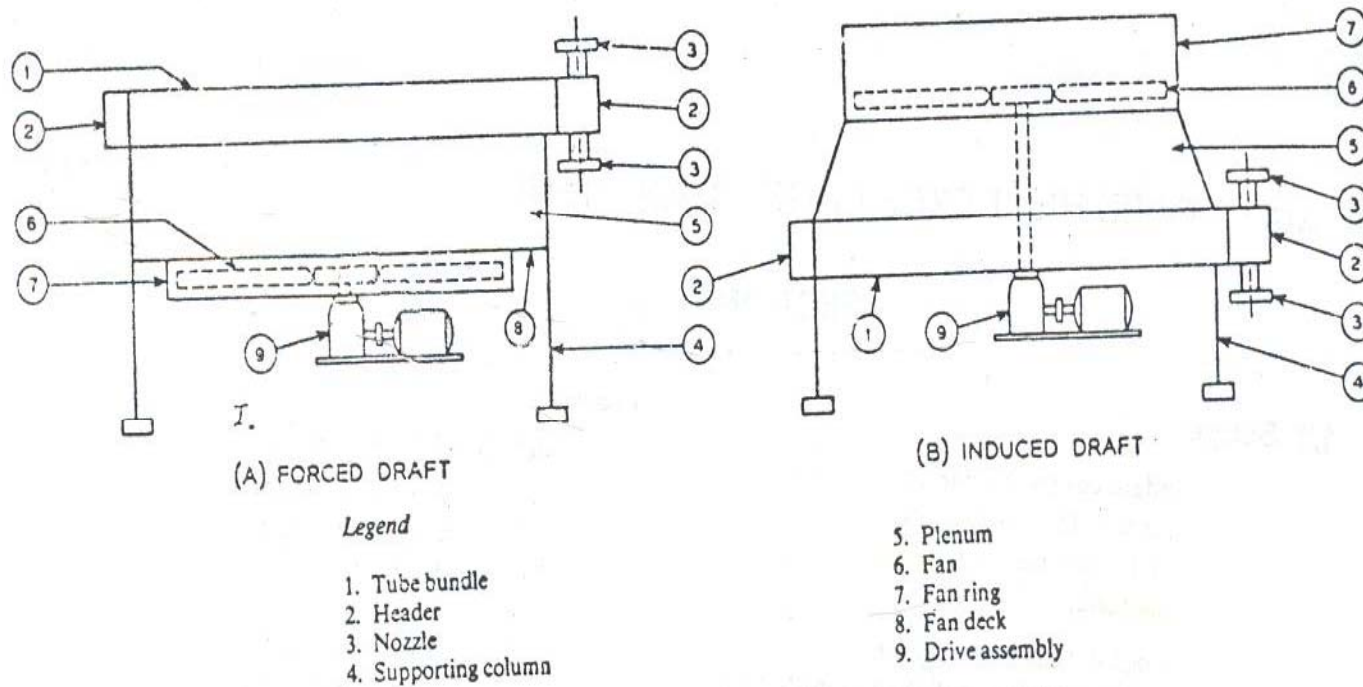


Figure 1—Typical Components of an Air-Cooled Heat Exchanger



# FORCED DRAFTING AIR COOLER

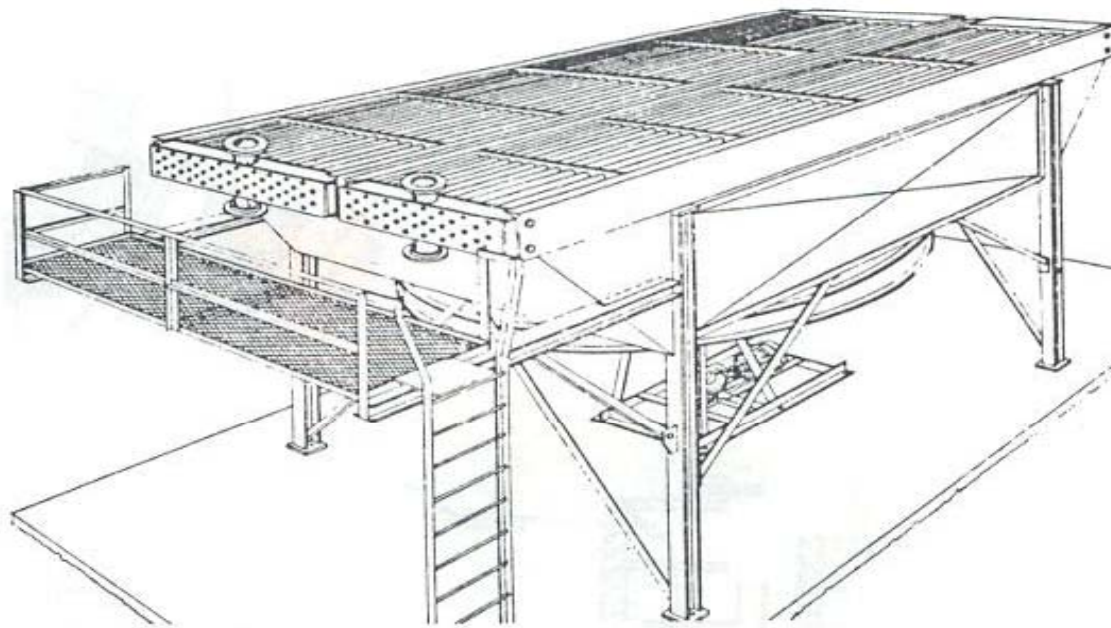
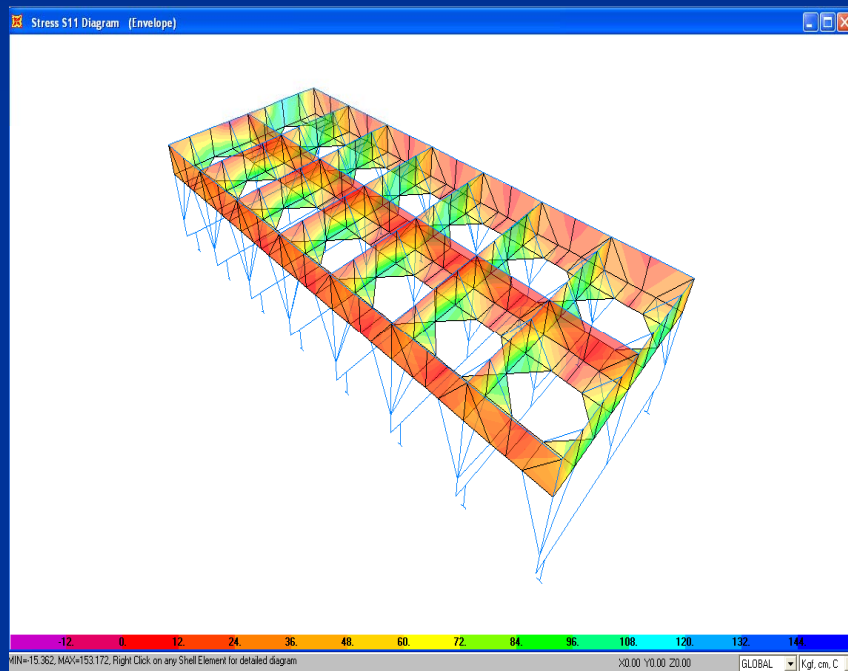


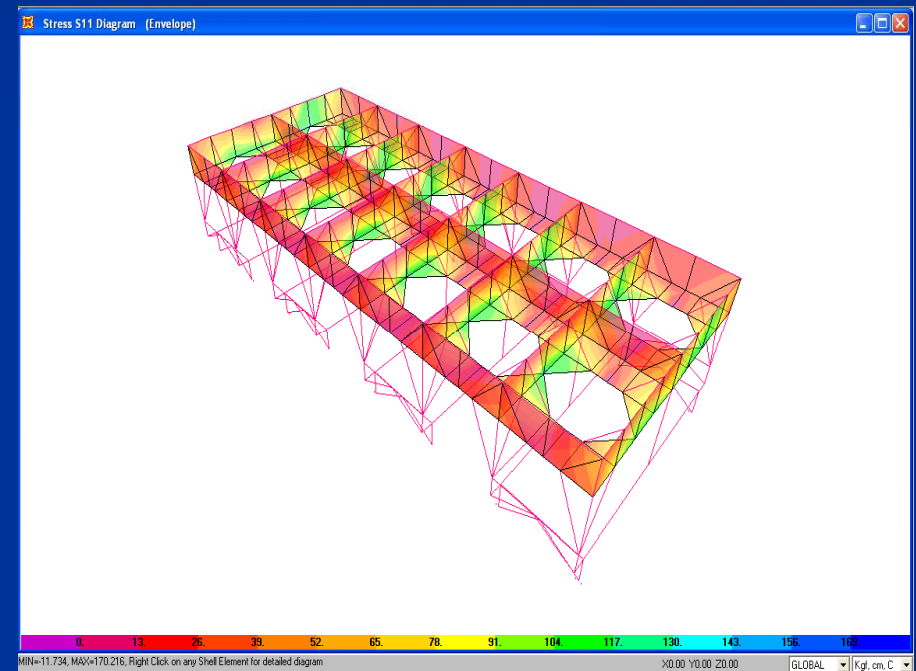
Figure 10-136. Typical forced draft air-cooled exchanger showing two exchanger sections and one fan. (By permission, Coyne Products, Inc.)



## Sample Stress Diagram for Air Coolers Using SAP

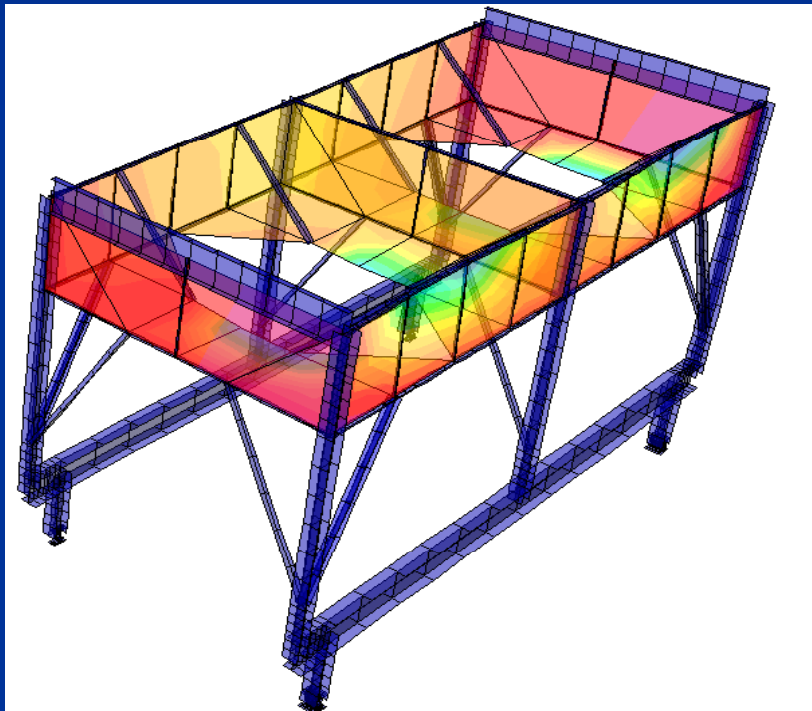


Before Retrofitting

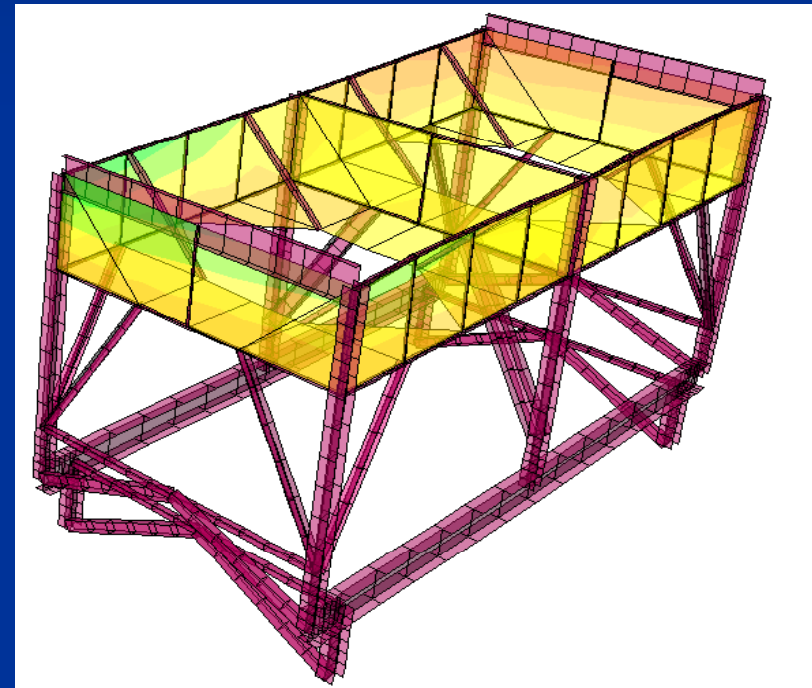


After Retrofitting

## Sample Stress Analysis for Air Coolers Using SAP

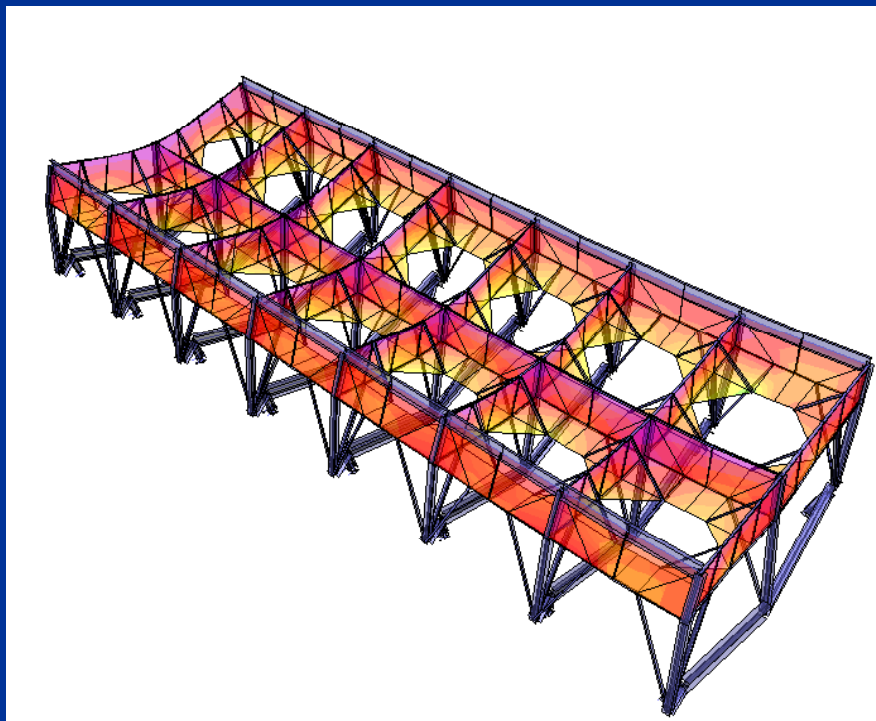


Before Retrofitting

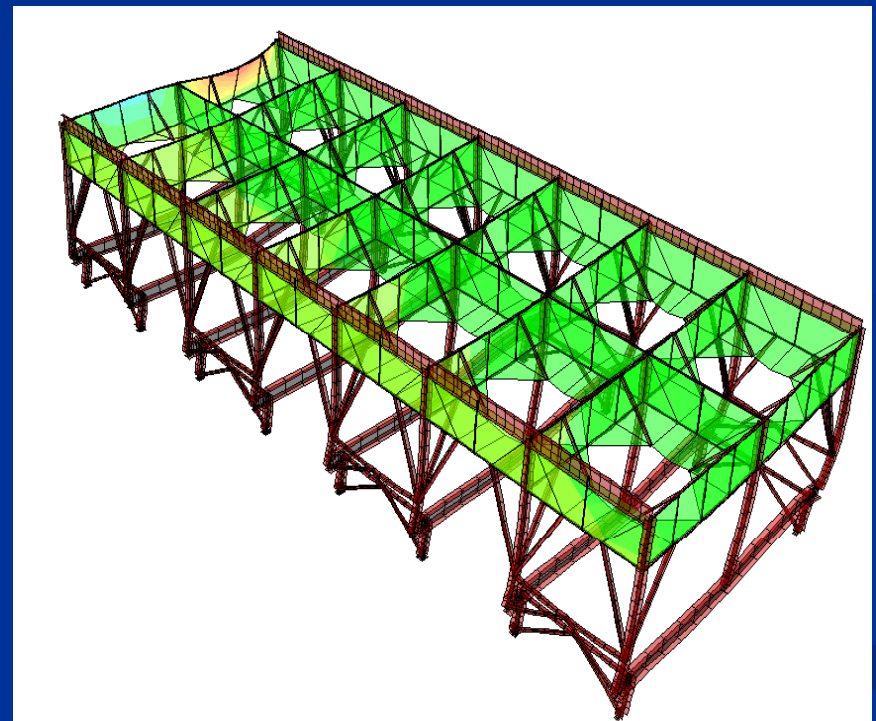


After Retrofitting

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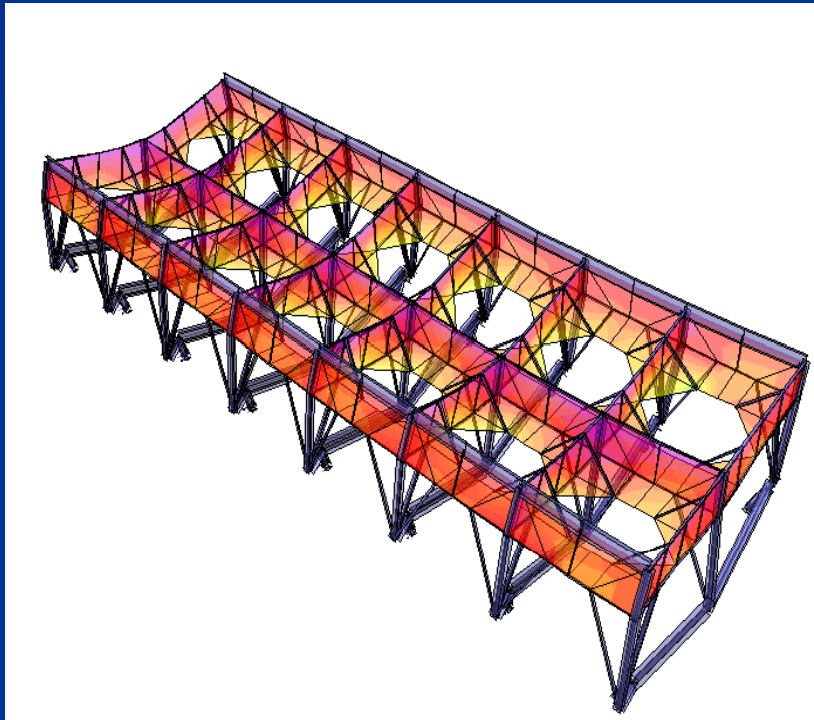


Before Retrofitting

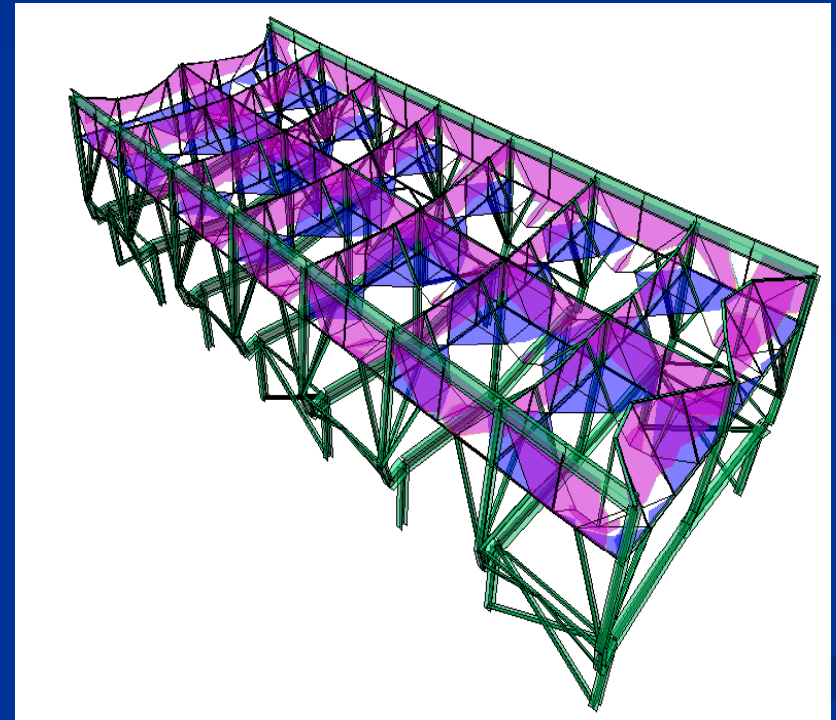


After Retrofitting

## Sample Stress Analysis for Air Coolers Using SAP

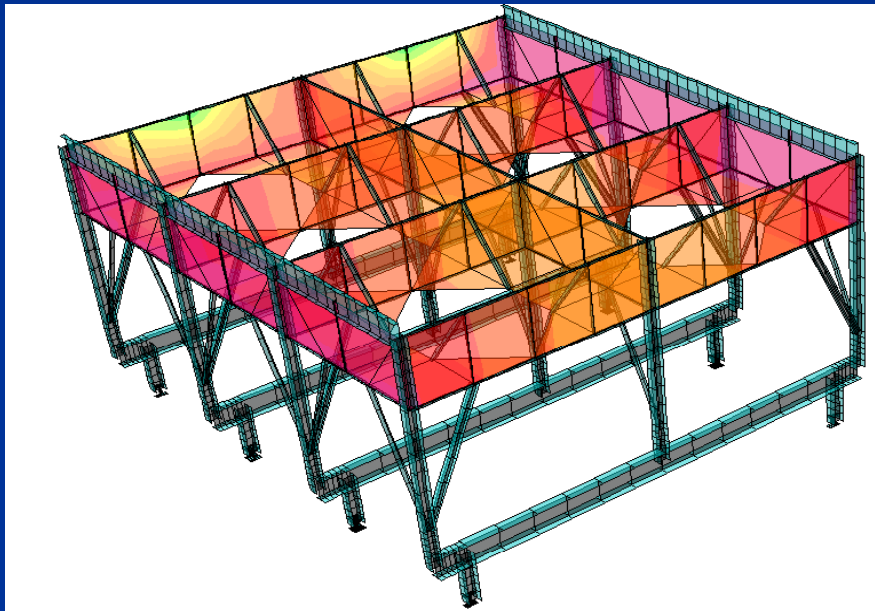


Before Retrofitting

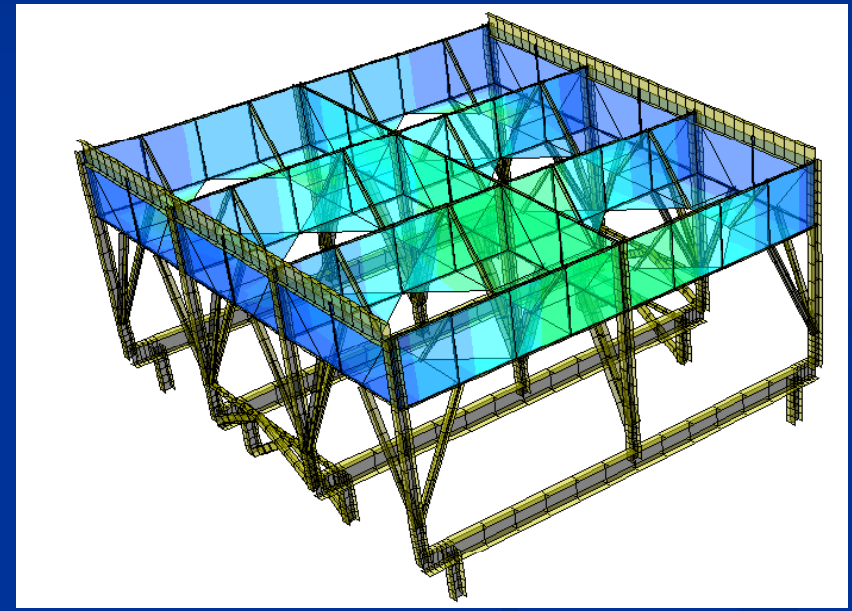


After Retrofitting

## Sample Stress Analysis for Air Coolers Using SAP



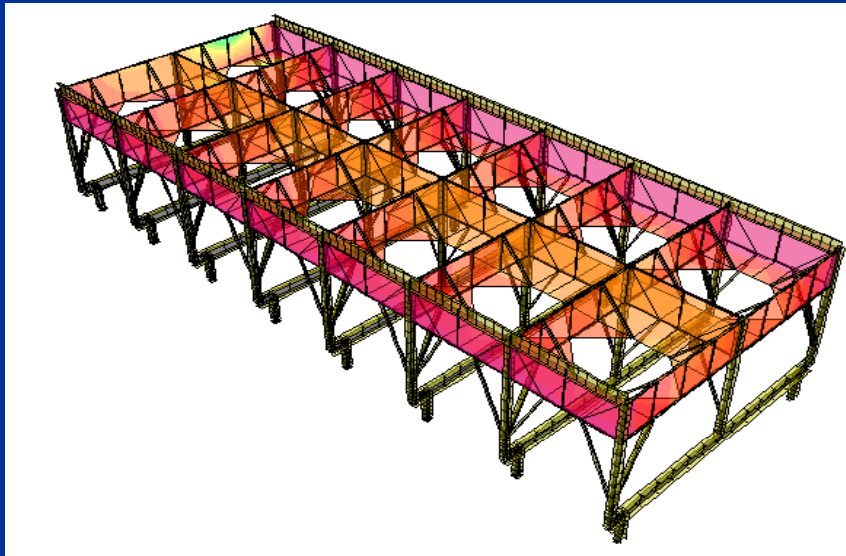
Before Retrofitting



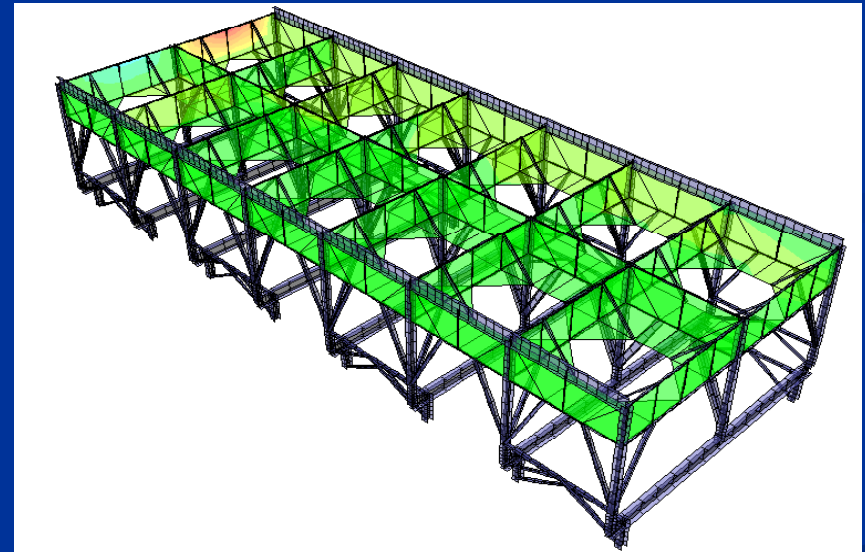
After Retrofitting



## Sample Stress Analysis for Air Coolers Using SAP



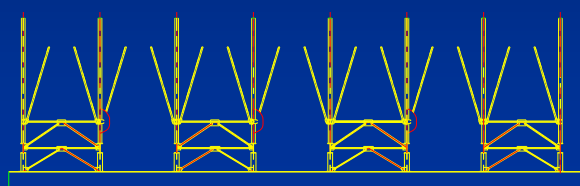
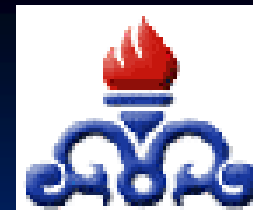
Before Retrofitting



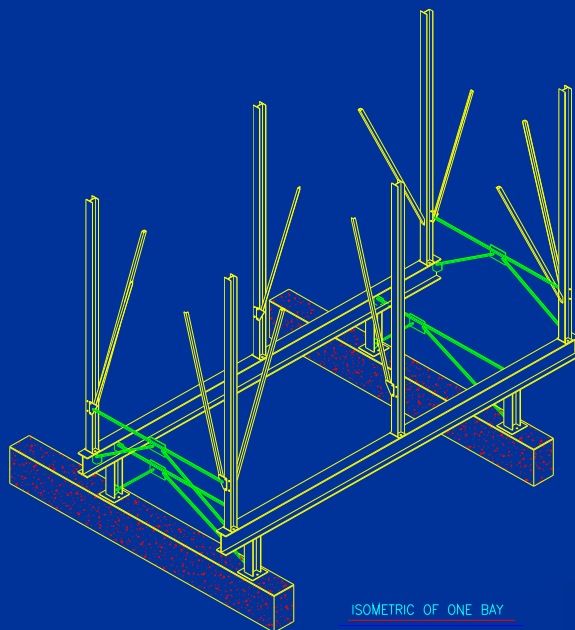
After Retrofitting

# 3- SAMPLE DATA SHEETS OF AIR COOLER







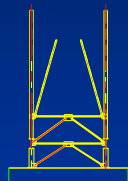
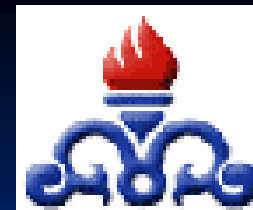
GENERAL ASSEMBLY OF AIRCOOLER  
2E - 101



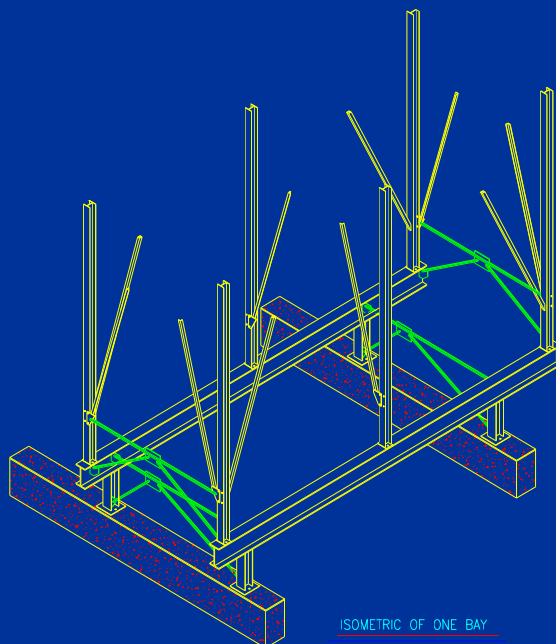
ISOMETRIC OF ONE BAY

NOZZLES					DESIGN DATA		SHELL	TUBE	JACKET
NOZZLE	SIZE	RATING/TYPE	QTY.	SERVICE	EARTH QUAKE	ZONE	4	4	
N1	—	150,W.N.,R.F.	1	INLET	DESIGN PRESSURE	KPa g	—	—	
N2	—	150,W.N.,R.F.	1	OUTLET	DESIGN TEMPERATURE	°C	178	178	
					FLUID SPECIFIC GRAVITY	Kg/cm <sup>3</sup>	—	—	
					HEAT EXCHANGER SURFACE	m <sup>2</sup>	—	—	
					HEAT TREATMENT		No	—	
					X-RAY TEST		SPOT	SPOT	
					JOINT EFFICIENCY	(%)	85	85	
					CORROSION ALLOWANCE	mm	3.2	3.2	
					GEOMETRIC CAPACITY	m <sup>3</sup>	—	—	
					INSPECTION INSTITUTE		—	—	
MATERIALS									
SHELL	SA516-Gr.60								
HEADS	—								
NOZZLE FLANGES	SA106 B								
NOZZLE NECKS & PIPES	SA106-Gr.A								
STUD BOLTS/EX. NUTS	SA193-Gr.B7/SA194-Gr.2H								
BOLTS	SA36								
BODY FLANGE	SA105 N								
BASE PLATE					DESIGN CODE : ASME VIII DIV.1-2001- API 661				
STEEL STRUCTURE	ST37				EARTH QUAKE CODE : UBC 1997				
					WEIGHTS				
					BUNDEL .....Kg				
					WATER FILLED .....Kg				
					LOADS AT SUPPORT BASE				
					ERECTION		OPERATION		HYDR. TEST
					Q Kg		SEE NEXT PAGES		

3									
2									
1									
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DRAWING NO.			SHEET NO.			REV.			
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GENERAL ASSEMBLY OF AIRCOOLER  
2E - 162

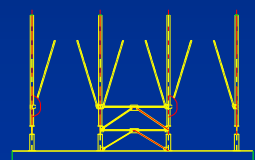
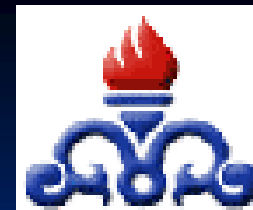


ISOMETRIC OF ONE BAY

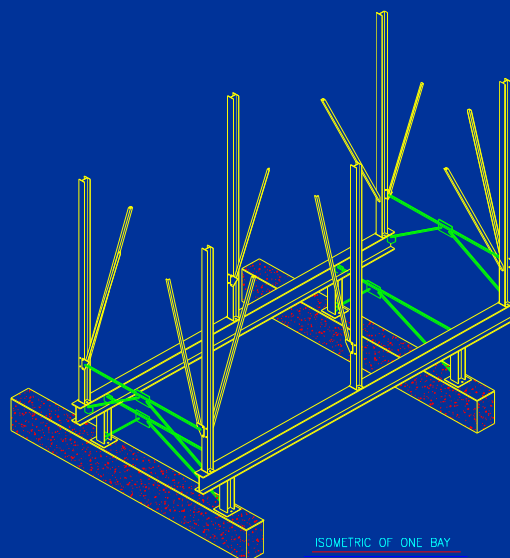
N1	-	150.W.N.,R.F.	1	INLET	DESIGN PRESSURE	KPa g	606	606
N2	-	150.W.N.,R.F.	1	OUTLET	DESIGN TEMPERATURE	°C	146	146
					FLUID SPECIFIC GRAVITY	kg/cm <sup>3</sup>	-	-
					HEAT EXCHANGER SURFACE	m <sup>2</sup>	-	-
					HEAT TREATMENT		No	-
					X-RAY TEST		SPOT	SPOT
					JOINT EFFICIENCY	(%)	85	85
					CORROSION ALLOWANCE	mm	3.2	3.2
					GEOMETRIC CAPACITY	m <sup>3</sup>	-	-
					INSPECTION INSTITUTE		-	-
MATERIALS								
SHELL		SA285-Gr.C						
HEADS		-						
NOZZLE FLANGES		SA181 GR I OR II						
NOZZLE NECKS & PIPES		SA106-Gr.A						
STUD BOLTS/EX. NUTS		SA193-Gr.B7/SA194-Gr.2H						
BOLTS		SA36						
BODY FLANGE		SA105 N						
BASE PLATE					DESIGN CODE : ASME VIII DIV.1-2001- API 661			
STEEL STRUCTURE		ST37			EARTH QUAKE CODE : UBC 1997			
					WEIGHT			
					BUNDEL	.....Kg		
					WATER FILLED	.....Kg		
					LOADS AT SUPPORT BASE			
					ERECTION		OPERATION	
					Q. Kg		SEE NEXT PAGE	

3								
2								
1								
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GENERAL ASSEMBLY OF AIRCOOLER  
2E - 117





ISOMETRIC OF ONE BAY

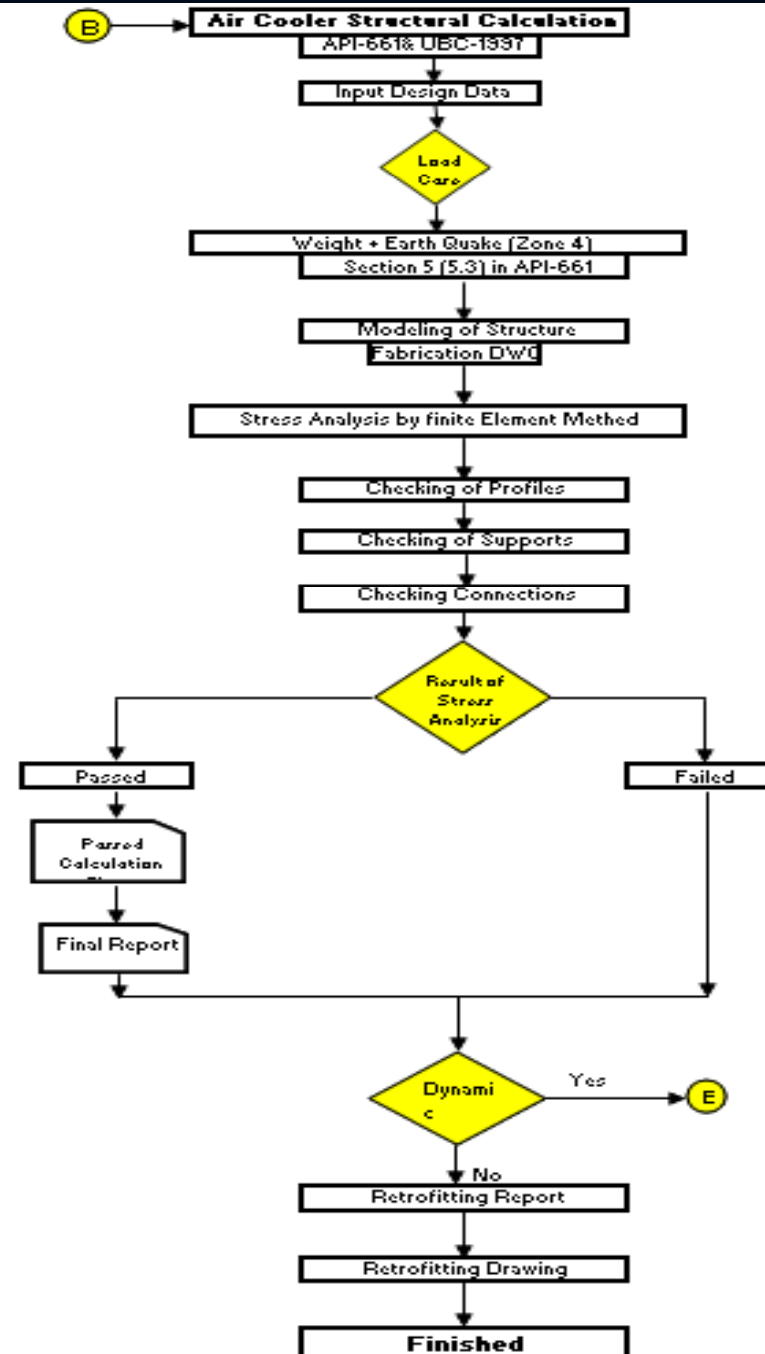
NOZZLES				DERION DATA		INSUL	TUBE	JACKET
NOZZLE	SIZE	RATING/TYPE	QTY.	SERVICE	EARTH QUAKE	ZONE	4	4
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N2	-	150.W.N.R.F.	1	OUTLET	DESIGN TEMPERATURE	°C	178	178
					FLUID SPECIFIC GRAVITY	kg/cm <sup>3</sup>	-	-
					HEAT EXCHANGER SURFACE	m <sup>2</sup>	-	-
					HEAT TREATMENT	No	-	-
				MATERIALS		X-RAY TEST	SPOT	SPOT
SHELL	SA516-G-60			JOINT EFFICIENCY		(%)	85	85
HEADS	-			CORROSION ALLOWANCE		mm	3.2	3.2
NOZZLE FLANGES	SA106 B			GEOMETRIC CAPACITY		m <sup>3</sup>	-	-
NOZZLE NECKS & PIPES	SA106-G-A			INSPECTION INSTITUTE		-	-	-
STUD BOLTS/EX. NUTS	SA193-G-87/SA194-G-2H							
BOLTS	SA36							
BODY FLANGE	SA105 N							
BASE PLATE				DESIGN CODE : ASME VIII DIV.1-2001- API 661				
STEEL STRUCTURE	S137			EARTH QUAKE CODE : UBC 1997				
				WEIGHTS				
				BUNDEL		.....Kg		
				WATER FILLED		88894.....Kg		
				LOADS AT SUPPORT BASE				
				ERECTION		OPERATION	HYDR. TEST	
				Q Kg		SEE NEXT PAGES		

3								
2								
1								
0	83.11.21	FIRST ISSUED	M.H.	F.R.	Z.N.	H.A		
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DRAWING NO.	SHEET NO.	REV.
EQ-N-M-D-2E117-01-00	1 OF 1	0

# 4- DESIGN FLOWCHART OF AIR COOLER



## Chapter 1:

### *"General Information"*

- This calculation sheet is prepared based on checking the Air cooler (2E-411) against earthquake (zone 4).
- This Air cooler was designed against earthquake (zone 3).
- Tehran oil refining co. has requested FAP co. to redesign this equipment based on

*UNIFORM BUILDING CODE (U.B.C.1997)*

*AMERICAN INSTITUTE OF STEEL CONSTRUCTION (A.I.S.C.)*

- The procedure of this redesign is as follow:
  - 1) Modeling of Air cooler by SAP2000, based on floor datasheet & fabrication drawings which are taken from Tehran refinery Archive, and checking the model based on zone 4.
  - 2) According to the results of analyze of model, report that the structure has Passed or Failed.

## Chapter 2:

### *"Modeling Conditions"*

- The connection of columns to base plates are assumed modify "Simple Support".
- The connection of bracing are "Simple Support".
- The connection of beams to girders are assumed "Simple Support".
- The connection of girders to columns are assumed "Simple Support".
- All dimensions are in (cm) unless otherwise indicated.
- All loads are in (kg) unless otherwise indicated.



## Chapter 3:

### *"Loading"*

#### 3.1) Dead Loads

The loads to be considered in the mode shall be the total weight of structural steelwork and all material permanently fastened there to or supported thereby.

#### 3.2) Live Loads

The live load shall be take as 100 k g/cm<sup>2</sup> (including rainfall and any human Loads) on platforms.

#### 3.3) Earthquake Loads

The earthquake loads on the Air cooler shall be calculated from U.B.C (1997)

$$V = \frac{C_v I}{R T} W$$

additionally, for seismic zone 4, the total base shear also not be less than the following:

$$V = \frac{1.6 Z N_v}{R T} W$$

where

$N_v$	=	Near-source factor	=	<u>12</u>
$C_v$	=	Seismic coefficient	=	<u>0.96 N<sub>v</sub> = 1.152</u>
$I$	=	Importance factor	=	<u>1.25</u>
$R$	=	Reduction factor	=	<u>5.6</u>
$T$	=	Elastic fundamental period	=	<u>0.169</u>
$Z$	=	Seismic zone factor	=	<u>0.4</u>

## Chapter 3:

### *"Loading"*

#### 3.1) Dead Loads

The loads to be considered in the mode shall be the total weight of structural steel work and all material permanently fastened there to or supported thereby.

#### 3.2) Live Loads

Calculated story drift,  $\Delta_{sd}$ , shall not exceed the following.

For  $T \leq 0.6$  sec  $\Delta_{sd} \leq 0.025H$  (Story Height)

For  $T > 0.6$  sec  $\Delta_{sd} \leq 0.020H$

$\Delta_{sd}$  shall be computed as follows :

$$\Delta_{sd} = 0.7 R \Delta_s$$

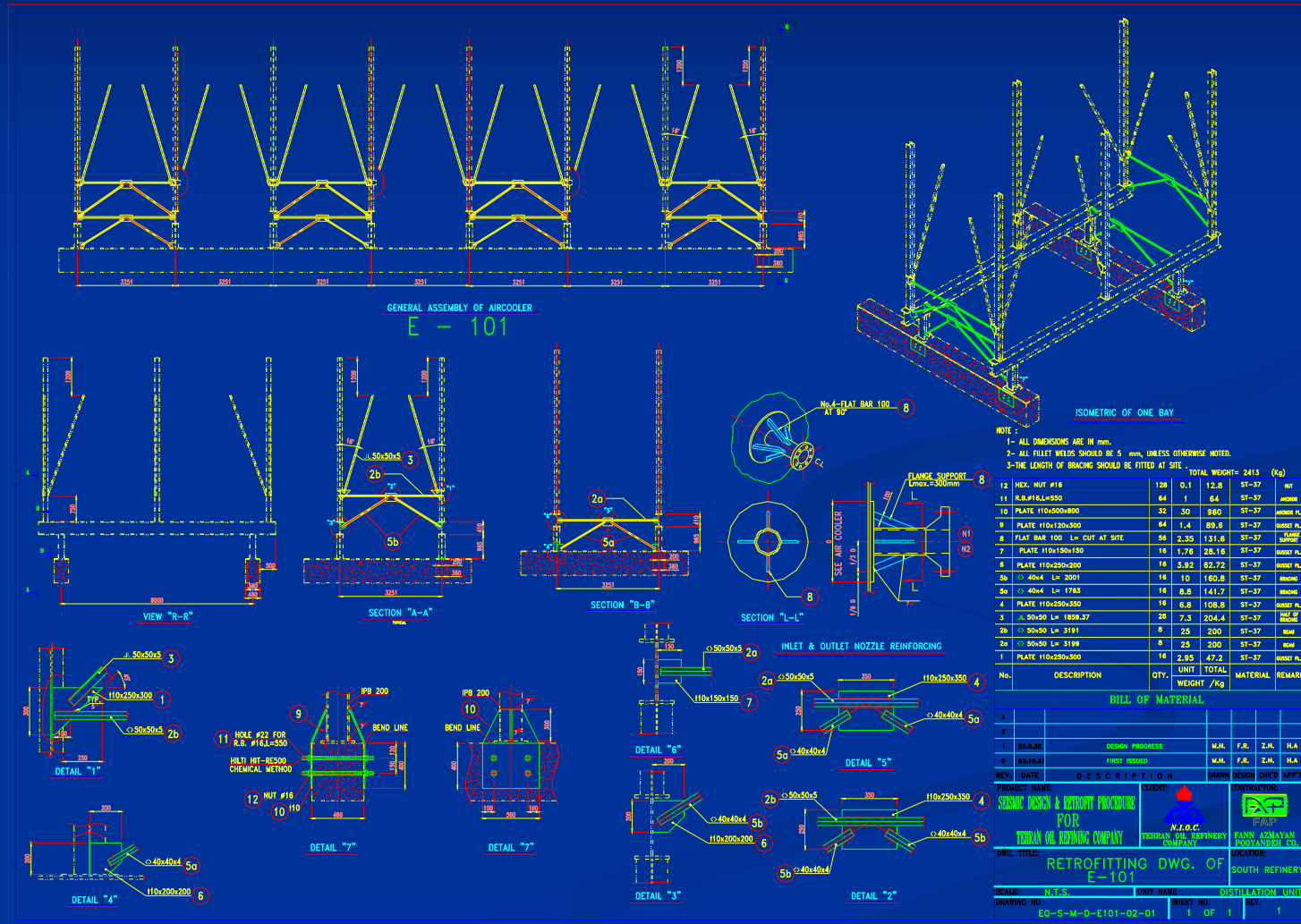
where  $\Delta_s$  is drift of design seismic forces.

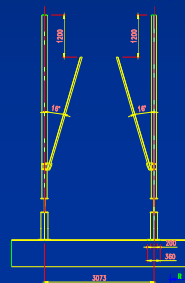
# 5- DIFFERENT TYPE OF RETROFITTING OF AIR COOLER

# TYPICAL FAILURE IN AIR COOLERS:

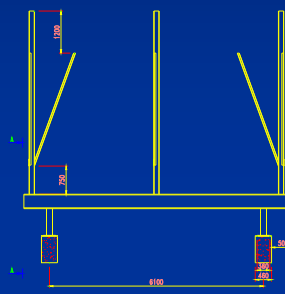
- 1- BASE PLATE FAILURE IN AIR COOLERS.
- 2- COLUMN FAILURE IN AIR COOLERS.
- 3- ANCHOR BOLTS FAILURE IN AIR COOLERS.

# Retrofitting Sample Drawing for Air Coolers

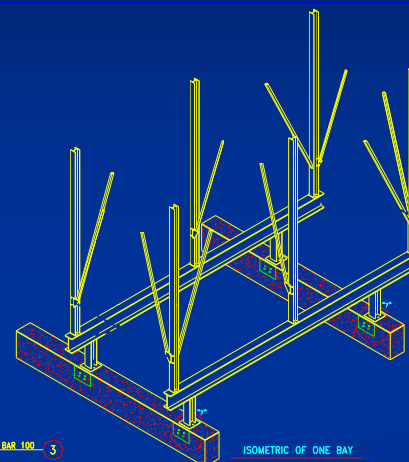




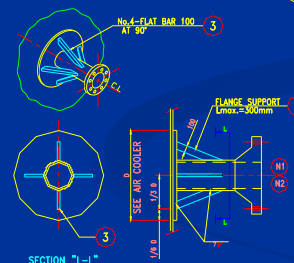
GENERAL ASSEMBLY OF AIRCOOLER  
E - 205



VIEW "R-R"



ISOMETRIC OF ONE BAY



### INLET & OUTLET NOZZLE REINFORCING

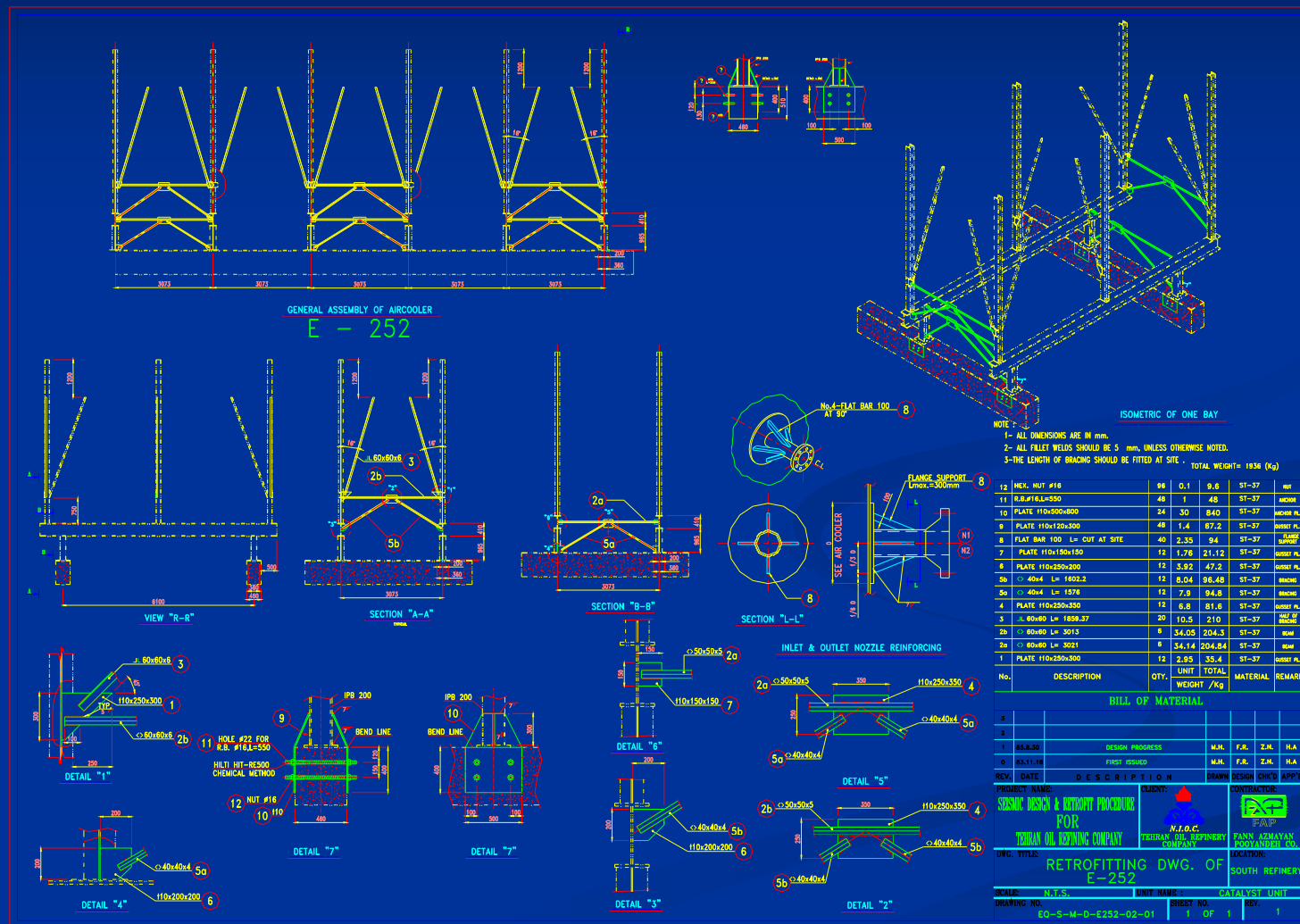
NOTE :

- 1- ALL DIMENSIONS ARE IN mm.
- 2- ALL FILLET WELDS SHOULD BE 5 mm, UNLESS OTHERWISE NOTED.
- 3-THE LENGTH OF BRACING SHOULD BE FITTED AT SITE .

		TOTAL WEIGHT= 355 (kg)				
7	HEX. NUT #16	32	0.1	3.2	37-37	IN
6	BLK.#16x1/2x550	16	1	16	57-57	IN
5	PLATE 110x500x800	6	50	240	57-37	MECH
4	PLATE 10x120x300	16	14	22.4	57-37	WELD
3	PLAT BMR 100 L= CUT AT SITE	6	2.35	16.8	57-37	WELD
2	1/2" ROVDR L= 1859.37	4	10.5	42.03	57-37	WELD
1	PLATE 110x250x300	4	2.95	11.76	57-37	MECH
No.	DESCRIPTION	QTY.	UNIT	TOTAL	MATERIAL	REMARKS

## BILL OF MATERIAL

3											
1	85.8.20		DESIGN PROGRESS			N.M.	F.D.	Z.M.	H.		
2	85.11.17		FINAL DESIGN			N.M.	F.D.	Z.M.	H.		
REV.	DATE	DESCRIPTION				DRAWN		CHECKED			
PROJECT NAME			CLIENT			CONTRACTOR					
SENSING MESH & AUTOMATIC PROTECTING FOR THERMAL OIL RADIATING COMPANY			 THERMAL OIL RADIATING COMPANY			 P&S ENGINEERING					
DWG. TITLE			THERMAL OIL RADIATING COMPANY			THERMAL OIL RADIATING COMPANY			P&S ENGINEERING		
RETROFITTING DWG. OF						LOCATION					
E-205						SOUTH NEPHIN					
SCALE: N.T.S.			UNIT NAME			ANALYST			UNIT		
DRAWING NO.			SHEET NO.			REV.					





# RESULT :

- 1- DECREASING THE OVERTURNING MOMENT FOR AIR COOLERS BY ADDING BRACING & COLUMN.
- 2- USE EXTRA ANCHOR BOLTS IN NEW LOCATION .
- 3- INCREASING THE THICKNESS OF BASE PLATE BY MULTI LAYERS PLATE AND PLUG WELDS FOR AIR COOLERS.

# THE END