공주 천연가스 발전소 주기기 및 부속설비 구매

CONTRACT NO. : 제 P-GJ01-23M01-01호

ITEM : SURFACE CONDENSER

DOC. TITLE : FOUNDATION LOAD CALCULATION FOR SURFACE CONDENSER

DOCUMENT REVIEW STATUS.

	FILE NO. :
KOREA DISTRICT HEATING ENGINEERING CO., LTD.	

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CONTENT

1. SCOPE AND PURPOSE

1.1 Scope

This foundation load calculation sheet is in scope of load in condenser for Subjected Power Project.

1.2 Purpose

This Technical Evaluation Sheet is to verify & evaluate the condenser foundation load at design operating condition for Subjected Power Project.

2. CODES & STANDARDS

HEI : Heat Exchange Institute 12th Edition (Standards for Steam Surface Condensers)
UBC , IBC , ASCE 7-10 , KBC , KECG 6801-2021 , KECG 2701-2021
ACI : American Concrete Institute
BHI Design Guide

3. GENERAL RULES & GUIDE OF CONDENSER FOUNDATION SYSTEM

3.1 General

There are a variety of condenser support method that can be used in power plant installations. Each design has many variables but depend primarily on the turbine casing allowable loads. Other influencing factors are ; seismic criteria, STG exhaust type, circulating water pipe layout, etc.
Condenser manufacturer and foundation designers to exchange sufficient information such that an acceptable arrangement is selected and agreed to by all parties.

3.2 Condenser hard mounted to concrete base

The condenser manufacturer calculates the net force as the arrangement dictates and resultant loads are presented to be plant foundation designers for approval.

The placement of expansion joint in CW piping adjacent to the condenser is common practice. When joints are used, they normally require control rods with compression sleeves to prevent large unbalanced forces from over loading the condenser and piping components.

Condensers are steam side filled with water test after field installation. The condenser manufacturer evaluates structural integrity and advises the plant foundation designer of all loads acting at the supports.

4. WEIGHT CALCULATION OF CONDENSER

4.1 Empty Weight Calculation

Wte (Total Empty Weight) = $\sum$ Wen = 260,000 kgf

Where)

We1 (Weight of shell and hotwell without tubes)	102,000	kgf
We2 (Weight of left side waterbox)	8,400	kgf
We3 (Weight of right side waterbox)	15,200	kgf
We4 (Weight of transition)	44,800	kgf
We5 (Weight of expansion joint)	5,000	kgf
We6 (Weight of extended neck with other)	5,100	kgf
We7 (Weight of foundation)	3,500	kgf
We8 (Weight of tube)	76,000	kgf

4.2 Operating Weight Calculation

Wto (Total Operating Weight) = Wte + $\sum$ Won = 436,000 kgf

Where)

Wo1 (Weight of water in tubes)	72,000	kgf
Wo2 (Weight of water in hotwell)	58,700	kgf
Wo3 (Weight of water in left side waterbox)	20,640	kgf
Wo4 (Weight of water in right side waterbox)	24,660	kgf

4.3 One Bundle Operating Weight Calculation

Wtoh (Total Operating Weight) = Wte + $\sum$ Wohn = 377,350 kgf

Where)

Woh1 (Weight of water in tubes)	36,000	kgf
Woh2 (Weight of water in hotwell)	58,700	kgf
Woh3 (Weight of water in left side waterbox)	10,320	kgf
Woh4 (Weight of water in right side waterbox)	12,330	kgf

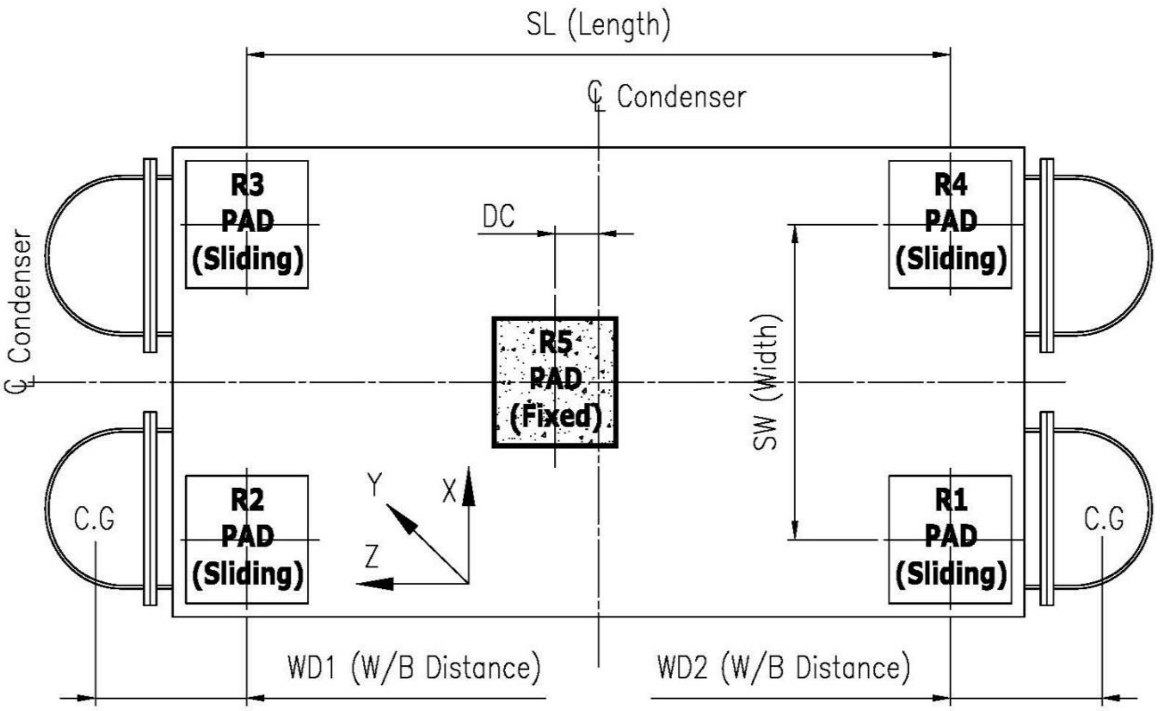
4.4 Flooded Weight Calculation

Wtf (Total Flooded Weight) = Wte + $\sum$ Wfn = 884,000 kgf

Where)

Wf1 (Weight of water in shell & hotwell)	338,000	kgf
Wf2 (Weight of water in transition)	218,000	kgf
Wf3 (Weight of water in expansion joint)	23,000	kgf
Wf4 (Weight of water in extended neck)	45,000	kgf

5. SUPPORT PAD ORIENTATION OF CONDENSER



Where)

SL (Length of Foundation Pad Center)				9,714	mm
SW (Width of Foundation Pad Center)				5,960	mm
WD1 (Distance of CG for Left Side Waterbox)				951	mm
WD2 (Distance of CG for Right Side Waterbox)				1,193	mm
TL (Distance of CG for Transition)	X	493	Z	-219	mm
EL (Distance of CG for Expansion Joint)	X	0	Z	0	mm
NL (Distance of CG for Extended Neck)	X	0	Z	0	mm
DC (Distance of R5 from Condenser Center at Z-Dir.)				0	mm

(Left : + , Right : -)

Note)

X-Axis : Perpendicular to Tube , Y-Axis : Up and Down , Z-Axis : Parallel to Tube

6. WEIGHT LOAD CALCULATION OF CONDENSER

6.1 Operating Vacuum Load Calculation

Pvo (Load for Vacuum Oper.) = A_{EXD} × Pvacuum			=	408,765	kgf
STG Exhaust Duct Inside Area (A_{EXD})		Rectangular	=	38,760,000	mm^2
5,700 Width or Dia.	×	6,800 Length		Inside Base	(Unit : mm)
Pvacuum (F.V Pressure)		15 psi	=	0.0105	kgf/mm^2

6.2 Summary Table of Weight Load

(Unit : kgf)

Condition	R1	R2	R3	R4	R5	Remark
Empty (Note.1)	31,092	26,332	27,659	32,545	142,372	
Operation with Vacuum (Note.2)	20,382	12,604	13,931	21,835	-41,517	
Operation without Vacuum (Note.3)	58,704	50,926	52,253	60,156	213,961	
One Bundle Operation with Vacuum (Note.4)	17,607	10,583	-3,138	2,502	-58,968	
One Bundle Operation without Vacuum (Note.5)	55,929	48,905	35,183	40,823	196,510	
Flooded (Note.6)	86,980	80,682	88,466	95,500	532,372	

Total Empty Weight (Wte)	=	260,000	kgf
Total Operating Weight with Vacuum (Wto)	=	27,235	kgf
Total Operating Weight without Vacuum (Wto)	=	436,000	kgf
Total One Bundle Operating with Vacuum Weight (Wtoh)	=	-31,415	kgf
Total One Bundle Operating without Vacuum Weight (Wtoh)	=	377,350	kgf
Total Flooded Weight (Wtf)	=	884,000	kgf

Note)

1. Condenser shell and tube side are empty with atmospheric pressure in condenser ; i.e.. No Vacuum
2. The bundles are in operation with hotwell at normal liquid level and condenser shell side is under vacuum. Circulating water expansion joints are assumed to be tied.
   ; i.e.. No Hydraulic forces.
3. Condenser shell side is under no vacuum. The other conditions are the same note.2
4. The conditions is defined as only one(1) bundle in operation.
   (Base of Operating Bundle is R1,2 Pad side)
   Hotwell is at normal liquid level and condenser shell side is under vacuum.
5. Condenser shell side is under no vacuum. The other conditions are the same note.4
6. Water filled for field hydrostatic test in shell side only (tube side empty).
7. The Negative signs in above tables indicate Up-Lift.

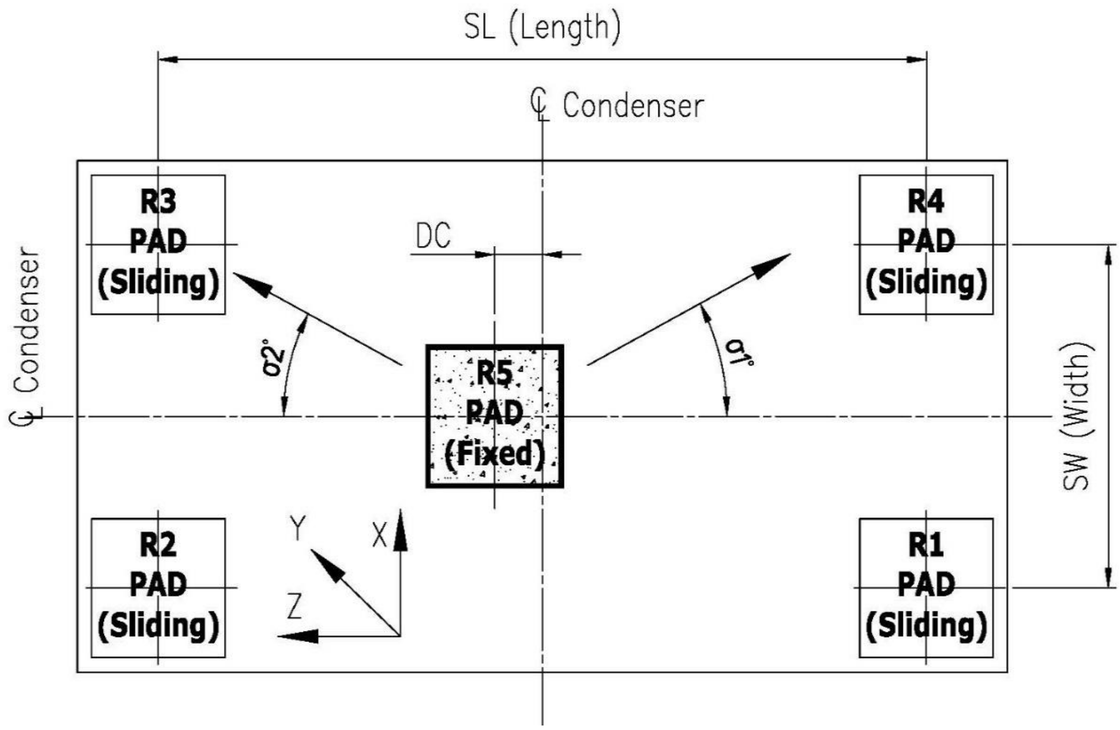
7. FRICTION LOAD CALCULATION OF CONDENSER

7.1 Friction Factor Definition

Friction Factor are based on friction factor of teflon plate with condenser at the load and seismic condition.

FFspad (Friction Factor for Sliding Pad) = 0.1

7.2 Direction & Angle of Pad Orientation for Friction Factor



σ_1° : Angle from Fixed (R5) to Sliding Point (R1,4) = 32 °

σ_2° : Angle from Fixed (R5) to Sliding Point (R2,3) = 32 °

Note)

1) If load of each pad was negative value (Up-lift load) , Friction load was None.

2) Fixed Point is Center Pad (R5)

7.3 Summary Table of Friction Load

(Unit : kgf)

Condition	Direction	R1 (±)	R2 (±)	R3 (±)	R4 (±)	Remark
Empty (Note.1)	X-axis	1,626	1,377	1,446	1,702	
	Z-axis	2,650	2,244	2,358	2,774	
Operation with Vacuum (Note.2)	X-axis	1,066	659	729	1,142	
	Z-axis	1,737	1,074	1,187	1,861	
Operation without Vacuum (Note.3)	X-axis	3,070	2,663	2,733	3,146	
	Z-axis	5,004	4,341	4,454	5,127	
One Bundle Operation with Vacuum (Note.4)	X-axis	921	553	0	131	
	Z-axis	1,501	902	0	213	
One Bundle Operation without Vacuum (Note.5)	X-axis	2,925	2,558	1,840	2,135	
	Z-axis	4,767	4,168	2,999	3,480	
Flooded (Note.6)	X-axis	4,549	4,219	4,626	4,994	
	Z-axis	7,414	6,877	7,540	8,140	

Fixed Point Foundation for Pad R5 must overcome friction load as below

X-Direction (Perpendicular of Tube direction)
R5mfx (Max. Friction Load of Pad R5) = **9,621** kgf
-. Max. (R1 + R2) or (R3 + R4) at all condition

Z-Direction (Parallel of Tube direction)
R5mfz (Max. Friction Load of Pad R5) = **15,554** kgf
-. Max. (R1 + R4) or (R2 + R3) at all condition

Remark) Friction Load without Seismic Condition

Note)

1. Condenser shell and tube side are empty with atmospheric pressure in condenser
   ; i.e.. No Vacuum
2. The bundles are in operation with hotwell at normal liquid level and condenser shell side is under vacuum. Circulating water expansion joints are assumed to be tied.
   ; i.e.. No Hydraulic forces.
3. Condenser shell side is under no vacuum. The other conditions are the same note.2
4. The conditions is defined as only one(1) bundle in operation.
   (Base of Operating Bundle is R1,2 Pad side)
   Hotwell is at normal liquid level and condenser shell side is under vacuum.
5. Condenser shell side is under no vacuum. The other conditions are the same note.4
   Hotwell is at normal liquid level and condenser shell side is under vacuum.
6. Water filled for field hydrostatic test in shell side only (tube side empty).

8. SEISMIC & WIND LOAD CALCULATION OF CONDENSER

8.1 Seismic Design Base Shear or Lateral Force Calculation (by KECG and KDS)

[KECG 6701,6801,6802-2021 and KDS 41 17 00]

시설물 관리등급 : 중요시설	제품 설비등급	:	2	등급
Z (지진구역계수)	지진구역 **I**	=	**0.11**	**g**
I (위험도계수)	재현주기 **2400** 년	=	**2.00**	
S (유효수평지반가속도)	= **Z** x **I**	=	**0.22**	
지반종류	암반지반	=	**S1**	
F_a (단주기 지반증폭계수)		=	**1.12**	
F_v (1초주기 지반증폭계수)		=	**0.84**	
T (구조물의 고유주기) = $C_T \cdot (h)^x$		=	**0.46**	**sec**
by KDS Para 7.2.4 "고유주기의 약산법"				
C_T	**철골편심가새골조 및 철골 좌굴방지가세골조**	=	**0.0731**	
x		=	**0.75**	
h (height in meter above the base)		=	**11.700**	**meter**
S_{DS} (단주기 설계스펙트럼가속도)	= $S \times 2.5 \times F_a$	=	**0.62**	
S_{D1} (1초주기 설계스펙트럼가속도)	= $S \times F_v$	=	**0.18**	
T_0	= $0.2 \times S_{D1} / S_{DS}$	=	**0.06**	**sec**
T_S	= S_{D1} / S_{DS}	=	**0.30**	**sec**
T_L		=	**5.0**	**sec**
FOR $T <= T_0$				
S_a (가속도응답스펙트럼)	= $0.6 \cdot (S_{DS}/T_0) \cdot T + 0.4 \cdot S_{DS}$	=	**3.10**	
FOR $T_0 < T <= T_S$				
S_a (가속도응답스펙트럼)	= S_{DS}	=	**0.62**	
FOR $T_S < T <= T_L$				
S_a (가속도응답스펙트럼)	= S_{D1}/T	=	**0.40**	
FOR $T > T_L$				
S_a (가속도응답스펙트럼)	= $S_{D1} \cdot T_L / T^2$	=	**4.32**	
I_p (중요도계수)		=	**1.50**	

F_p (설비 질량중심에 작용하는 설계지진력, 수평력)

	= $(0.4 \cdot a_p \cdot S_{DS} \cdot W_p) \cdot (1+2 \cdot z/h)/(R_p/I_p)$	=	**105,579**	**kgf**
F_p (최대설계지진력, 수평력)	= $1.6 \cdot S_{DS} \cdot I_p \cdot W_p$	=	**644,582**	**kgf**
F_p (최소설계지진력, 수평력)	= $0.3 \cdot S_{DS} \cdot I_p \cdot W_p$	=	**120,859**	**kgf**

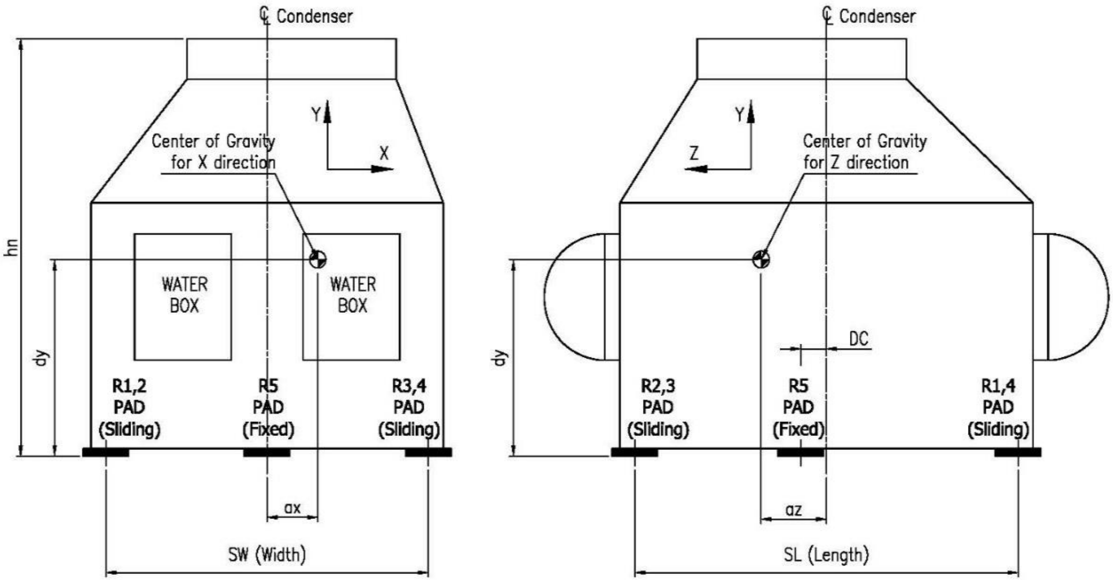
Note) F_p 는 최대설계지진력을 초과할 필요는 없으며 최소설계지진력 이상이 되어야 한다.

F_p (설계지진력, 수직력)	= $\pm 0.25 \cdot S_{DS} \cdot W_p$	=	**67,144**	**kgf**
F_E (Seismic Design Value between each F_p Value)		=	**120,859**	**kgf**

Where)

a_p : 1.0~2.5 사이값을 갖는 설비 증폭계수	=	**1.0**	
R_p : 설비반응수정계수	=	**2.5**	
W_p : 설비가동중량	=	**436,000**	**kgf**
z :구조물의 밑면으로 부터 설비가 부착된 높이	=	**3.732**	**meter**

8.2 Dimension & Center of Gravity for Seismic Calculation



hn (height in feet above the base)	=	**11,700**	**mm**	=	**38.4**	**feet**
dy (C.G for Y Direction)				=	**3,732**	**mm**
ax (C.G for X Direction)				=	**51**	**mm**
az (C.G for Z Direction)				=	**-189**	**mm**

8.3 Design Seismic Force Calculation

Vs (Design Seismic Force, F_E) = **120,859** **kgf**

8.4 Summary of Seismic Load

(Unit : kgf)

Condition	Direction	R1 (±)	R2 (±)	R3 (±)	R4 (±)	R5 (±)	Remark
X-Direction Seismic Event (Perpendicular to Tube)	X-axis	3,784	3,784	3,784	3,784	105,723	
	Y-axis	37,840	37,840	37,840	37,840	0	
	Z-axis	0	0	0	0	0	
Z-Direction Seismic Event (Parallel to Tube)	X-axis	0	0	0	0	0	
	Y-axis	23,216	23,216	23,216	23,216	0	
	Z-axis	2,322	2,322	2,322	2,322	111,573	

Note) The Negative Signs at Y-axis in above tables indicate up-lift.

- END -