



نگهداشت و افزایش تولید میدان نفتی بینک  
سطح الارض و ابنیه تحت الارض

عمومی و مشترک



شماره پیمان:  
053 - 073 - 9184

SPECIFICATION FOR FLEXIBILITY ANALYSIS

نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه
D01	0012	SP	PI	000	PEDCO	GNRAL	BK

شماره صفحه : 1 از 17

طرح نگهداشت و افزایش تولید 27 مخزن

SPECIFICATION FOR FLEXIBILITY ANALYSIS

نگهداشت و افزایش تولید میدان نفتی بینک



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D00	Aug. 2021	IFC	M.Asgharnejad	M.Fakharian	M.Mehrshad	
Rev.	Date	Purpose of Issue/Status	Prepared by:	Checked by:	Approved by:	CLIENT Approval

Class: 2

CLIENT Doc. Number: F0Z-707142

Status:



IDC: Inter-Discipline Check  
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## 0.0 INTRODUCTION

Binak oilfield in Bushehr province is a part of the southern oilfields of Iran, is located 20 km northwest of Genaveh city.

With the aim of increasing production of oil from Binak oilfield, an EPC/EPD Project has been defined by NIOC/NISOC and awarded to Petro Iran Development Company (PEDCO). Also PEDCO (as General Contractor) has assigned the EPC-packages of the Project to "Hirgan Energy - Design and Inspection" JV.

### GENERAL DEFINITION



The following terms shall be used in this document.

COMPANY:	National Iranian South Oilfields Company (NISOC)
PROJECT:	Binak Oilfield Development – General Facilities
EPD/EPC CONTRACTOR:	Petro Iran Development Company (PEDCO)
EPC CONTRACTOR:	Joint Venture of : Hirgan Energy – Design & Inspection(D&I) Companies
VENDOR:	The firm or person who will fabricate the equipment or material.
EXECUTOR:	Executor is the party which carries out all or part of construction and/or commissioning for the project.
THIRD PARTY INSPECTOR (TPI):	The firm appointed by EPC CONTRACTOR and approved by GC & COMPANY (in writing) for the inspection of goods.
SHALL:	Is used where a provision is mandatory.
SHOULD:	Is used where a provision is advisory only.
WILL:	Is normally used in connection with the action by COMPANY rather than by an EPC/EPD CONTRACTOR, supplier or VENDOR.
MAY:	Is used where a provision is completely discretionary.

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The amendments/supplement to the related IPS Standard(s) given in this document are directly related to the equivalent sections or clauses in the IPS Standard(s). For clarity, the section and paragraph numbering of the IPS Standard(s) has been used as long as possible. Where clauses

in IPS are referenced within this document, it shall mean those clauses are amended by this

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## 1.0 SCOPE

This specification gives amendment and supplement to IPS-E-PI-200(1), "Engineering Standard for Flexibility Analysis".

It shall be used in conjunction with data/requisition sheets for present document subject.

IPS-E-PI-200(1), covers the basic requirements for the flexibility analysis of piping systems in Oil, Gas and Petrochemical Industries.

The analysis shall consider the effects of Temperature, Pressure, Vibration, Loads, Fluid, Reactions and Environmental Factors.

## 2.0 NORMATIVE REFERENCES



Following Codes, Standards and Documents shall be added to the IPS-E-PI-200.

### 2.1 LOCAL CODES AND STANDARDS



- IPS-E-PI-240(2) "Engineering Standard for Plant Piping Systems"

### 2.2 THE PROJECT DOCUMENTS

- ASME Section VIII Div. 2 (Boiler and Pressure Vessel Codes)
- API 620 "Design and Construction of Large, Welded, Low-Pressure Storage Tanks"
- UBC (1997+Addendum) (Uniform Building Code)
- ASME B31.3: Pressure Piping

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- ASME B31.1: Power Piping
- ASME B31.8: Gas Transmission and Distribution Piping Systems
- IPS-E-PI-200
- API Standard 560: Fire Heaters for General Refinery Services
- API Standard 610: Centrifugal Pumps for General Refinery Services
- API Standard 616: Gas Turbine
- API Standard 617: Centrifugal Compressors for General Refinery Services
- API Standard 618: Reciprocating Compressor for General Refinery Services
- API Standard 650: Welded Steel Tanks for Oil Storage
- API Standard 661: Air Cooler & Heat Exchanger for General Refinery Services
- NEMA Standard Publication SM-23: Steam Turbines for Mechanical Drive Services
- WRC 107/198: Local Stresses in Spherical and Cylindrical Shells Due to External Loading
- UBC - Uniform building code
- API 611 "General purpose steam turbine for refinery services"
- API 612 "Special purpose steam turbine for refinery services"
- API 619 "Rotary-type positive displacement compressors for general refinery services"
- API 660 – Shell & tube Type heat exchangers for general refinery
- API RP 520 "Recommended Practice for the Design and Installation of Pressure-Relieving System in Refineries"
- WRC 297-Supplement to WRC 107
- EJMA "Standard of the Expansion Joint Manufacturers Association"
- ASME B 16.9 – Factory made wrought steel butt-welding fitting
- ASME B 16.5 – 2003 Steel pipe flanges and flanged fitting
- ASME B 16.11– Forged-steel fitting, socket-welding and threaded
- ASME B 16.25 – Butt-welding ends for pipe, valves, flanges and fitting
- ASME B 16.28 – Wrought steel butt-welding short radius elbow and return
- ASME B 36.10 – Wrought steel and wrought-iron pipe
- ASME B 16.47 – Large diameter carbon steel flanges (Series B)
- LISEGA – Lisega catalogue
- ASCE#7 – Minimum design load for building and other structures
- MSS-SP-58: Pipe hangers and supports (Material, design and manufacture)
- MSS-SP-69: Pipe hangers and supports (Selection and Application)
- BS7159: Design and construction of glass-reinforced plastics (GRP) piping systems for individual plants or sites.
- UKOOA: Specifications and recommended practice for the use of glass fiber reinforced plastic piping offshore
- WRC (Welding Research Council)
- 107/297 "Local Stresses in Cylindrical Shells Due to External Loading on Nozzles"

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- WRC 537 Precision equations and enhanced diagrams for local stresses in spherical and cylindrical shells due to external loadings for implementation of WRC Bulletin 107

## 2.3 THE PROJECT DOCUMENTS

BK-GNRAL-PEDCO-000-PR-DB-0001 Process Basis of Design

Plant Layout and Piping Design Criteria

Specification for Pipe Support

Specification for Allowable Nozzle Loads for Static Equipment

Piping and Pipeline Material Specification

Piping Standard Support Drawings

## 2.4 ENVIRONMENTAL DATA

Refer to "Process Basis of Design; Doc. No. BK-GNRAL-PEDCO-000-PR-DB-0001".

## 3.0 DEFINITION AND TERMINOLOGY

No amendments or supplements are to state.

## 4.0 UNITS

Using of SI units of CAESAR II is preferred.

## 5.0 PIPING STRESS ANALYSIS



The following specifications shall be complied with:

- Pipe support design based on IPS-G-PI-280 and Specification For Pipe Support (BK-GNRAL-PEDCO-000-PI-SP-0014).

### 5.1 GENERAL

Stress Analysis, calculation of reaction loads due to thermal expansion or contraction in piping systems and the selection of the type of supports shall be conducted in accordance with the criteria set in codes and standards referenced under sections 3. In the cases in which the flexibility of under examination



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piping system is found to be insufficient to absorb the imposed primary and secondary loads (e.g., weight and thermal loads respectively), those methods listed below shall be adopted, in the following order of preference:

- Introduction of restraints.
- Changing in piping routing and inserting proper pipe loops.
- Introduction of spring supports (variable or constant) to the piping system.
- Utilizing the reinforcing pad in pipe branches and nozzle intersection with equipment.
- Utilizing of proper type of metallic or elastomer expansion joint.
- Victaulic and dresser type coupling.
- Metal and elastomer hoses.
- And all in-line flexible connectors

The following data shall be used through stress analysis according to the given values and references:

- The allowance of displacement stress range (SA) is the limit of stress calculation referred in ASME B31.3 Para. 302.3.5.

- Value of stress intensification factor (SIF) for elbows, bends and tees which is used for stress analysis calculation shall be in accordance with ASME B31.3 Appendix "D". Data base of applied software can be used.

- Value of module of elasticity (E) which is used for stress analysis calculation shall be in accordance with ASME B31.3 Appendix "C", Table C-6. Data base of applied software can be used.

- Value of Poisson ratio (n) may be taken as 0.3 at all temperature for all ferrous metals. More accurate and authoritative data can be used if available. Data base of applied software can be used.



- Material for pipe shall be extracted from "piping material specification" of the project. Also material of insulation shall be extracted from "insulation specification" of the project. Data base of applied software could be used for material properties.

## 5.2 ANALYSIS CLASSIFICATION

All lines shall be reviewed for flexibility, stress and load calculation by experienced judgment, simplified or comprehensive methods.

## 5.3 EXPERIENCED JUDGMENT METHOD

This method comprises the lines which can be judged by relying upon normal experiences and practices of engineering design team. The piping systems in this scope need no formal analysis of adequate flexibility.

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#### 5.4 SIMPLIFIED METHOD

This method comprises the piping systems in which adequate flexibility and suitable pipe supports shall be provided by computer analysis. But providing of documented output for presentation to employer is not mandatory.

#### 5.5 COMPREHENSIVE METHOD

Computer analysis shall be generally used where there is any concern over the flexibility of a piping system and in particular where accurate calculations of values are required. (e.g., equipment nozzle, support, spring loads and displacement vector). Documented output shall be prepared for the piping systems which are covered by this method.

#### 5.6 STRESS ANALYSIS GRADE CLASSIFICATION

The lines of a piping system shall be classified into three (3) categories from stress analysis point of view including size, temperature, origin and destination of lines. These classifications, according to severity of operating condition and methods of analysis, are categorized as:

“Level 1” Grade – Experienced judgment method.

“Level 2” Grade – Simplified method.

“Level 3” Grade – Comprehensive method.

In general, computer analysis will be required for that listed in attached chart and table (Refer to Fig#1 & Fig#2). The listing is not intended to be exhaustive and address every eventuality, sound engineering judgment shall always prevail.

Fig # 1: General chart for lines which do not meet the table in Fig#2.

Fig#2 Lines with various type of boundary condition, fluid service, pressure rating and material.

### 6.0 LOAD AND STRESS CONSIDERATION IN PIPE STRESS ANALYSIS



#### 6.1 WEIGHT EFFECT

Weight load includes the weight of piping components (pipe, fitting, flange, valve ...), content, insulation and any in-line equipment, ice or snow shall be considered if applicable. The primary stress caused by weight as a part of SL shall not be more than allowable stress  $Sh$ . Another weight effect is tank settlement which shall be considered in a comprehensive calculation. The displacement caused by tank settlement as a secondary stress shall be considered as a data in displacement field of Caesar II spread sheet and the stress caused shall not be more than  $SA$ .

#### 6.2 HYDRO TEST

Hydrostatic test weight shall be taken into consideration as an occasional event for lines which have content with specific gravity less than 1.0. The applied stress due to hydrostatic test weight including weight and test pressure shall not be more than  $Sy$ .

In cases that extra supports are required only for HYD, the temporary supports shall be considered for piping during hydrostatic test period. Where applicable, hydrostatic test at grade is preferred and shall be

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BK	GNRAL	PEDCO	000	PI	SP	0012	D01																			

mentioned in relevant documents (e.g., isometric drawings, line list...). Note that hydrostatic test, wind, snow load, earthquake and expansion effects shall not be considered as acting concurrently.

### 6.3 PRESSURE EFFECTS

Design pressure shall be taken as the calculation pressure as per ASME B31.3, unless otherwise noted. The primary stress caused by pressure as a part of SL shall not be more than allowable stress Sh.

### 6.4 THERMAL EXPANSION AND CONTRACTION EFFECTS

- The difference between Max/Min ambient temperature and design temperature should be used for calculating maximum stress range.
- Max/Min operating temperature should be used for piping support, equipment nozzle load and spring hanger selection.
- Other thermal cases that should be considered are : Steam out , solar radiation , fire case , start up/shut down for towers, regeneration for reactors , destocking and stand by conditions.
- Installation temperature should be considered as 21°C.

### 6.5 FRICTION EFFECT

Friction effect in piping system includes the effect of frictional resistance to thermal movement of the pipe based on coefficient of friction.

Following friction factors shall be considered for computing the frictional resistance in stress analysis:

<u>Surfaces</u>	<u>Friction factor (<math>\mu</math>)</u>
Steel – Steel	0.3
Steel – Teflon	0.1
Steel – Concrete	0.5

### 6.6 DYNAMIC EFFECTS

#### 6.5.2 WIND

6.5.2.1. Wind loading shall be considered on the following piping to ensure structural integrity of pipe support structures and vessel shells when the pipe outside diameter (including insulation thickness) is 500 mm and over:

1. Lines that are routed down towers, columns or vertical drums.
2. Inlet lines to Air coolers.

The wind load shall be calculated by the equation shown below:


$$WL = 0.7 A.q$$

WL = wind load

A = Projected area (O.D. of pipe including the insulation multiplied by the unit length of the piping)

q = wind pressure (specific value)

Prevailing wind direction: W-E, NW-SE

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پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه																			
BK	GNRAL	PEDCO	000	PI	SP	0012	D01																			

Basic wind speed: refer to site condition.

Importance factor I=1.15

Exposure factor = C

Note-1: Wind load calculation shall not be considered for piping systems which have been located inside or in the shadow of a structure or a building.

Wind, earthquake, snow load, expansion effects and hydrostatic test loads shall not be considered as acting concurrently. The effect of wind load shall be considered on restriction points (e.g., supports and anchor points) but not for nozzle and Heater Tie-in points.

### 6.5.3 EARTHQUAKE

6.5.3.1. According to site condition, the seismic coefficient with forced acceleration shall be considered. CAESAR II facility (ASCE code) could be used for seismic coefficient calculations.

6.5.3.2. All critical piping systems (Level 3) shall be analyzed for seismic loads.

## 7.0 FLANGE LEAKAGE CRITERIA

The flange leakage shall be evaluated for all flanges on critical lines with rating  $\geq 600\#$  and also for critical lines which carry M fluid service.

The following formula for equivalent pressure can be used for this verification:

$$P_{eq} = 4F/\pi G^2 + 16M/\pi G^3$$

In which:

$P_{eq}$ : Equivalent pressure due to external loads (MPa).

F: Axial Force acting on the flange face due to weight and thermal expansion (operation case) of the pipe (N)

M: Bending moment acting on the flange face due to weight and thermal expansion (operation case) of the pipe (N mm)

G: Diameter of the gasket that reacts to the load



If the sum of the equivalent pressure calculated in this way and the operating pressure of the piping does not exceed the maximum pressure allowed by the rating of the flange joints as per ASME B 16.5, the applied external loads are acceptable. Also, evaluation of the flanges could be done according to ASME B&PVC Section III Subsection NC-3658.3 method. The flange load checking shall be considered in operating temperature and operating pressure.

## 8.0 ALLOWABLE LOADS ON EQUIPMENT NOZZLES

For all nozzle loads calculation shall be based on operating temperature.

In all below items , vendor data which have been specified in vendor GA is in first priority:

- Pump: 2xAPI 610 or vendor data
- Pressure vessel :Nozzle allowable load specification or vendor data
- Centrifugal compressor : 2xAPI 617 or vendor data. Displacement shall be submitted by vendor.

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	BK	GNRAL	PEDCO	000	PI	SP	0012	
							D01	

- Reciprocating compressor: Nozzle allowable loads and nozzle flange displacements shall be submitted by vendor. Compressor SUPPLIER shall carry out analogue study for compressor suction and discharge piping
- Turbine : 3xNEMA SM-23 or vendor data. Displacement shall be submitted by vendor.
- Air cooler : 3xAPI 661 or vendor data.
- Heater : 4x API 560 or vendor data. Allowable displacement shall be submitted by vendor.
- Other equipment and vendor package tie-in points should be considered in agreement with vendor.

## 9.0 DESIGN CONSIDERATION

### 9.1 EXPANSION JOINTS

Expansion Joints must be rated and evaluated against manufacture's allowable.

### 9.2 FIRE CASE

To be considered for flare lines. Temperature for the same to be considered as identified in the line list.

## 10.0 EXTENT OF ANALYSIS

No amendments or supplements are to state.

## 11.0 ANALYSIS SOFTWARE



Computer stress analysis for critical systems will be carried out using CAESAR-II (2018) or higher.

### 11.1 GEOMETRIC DATABASE

- CAESAR II library of piping will be utilized with nominal bore and schedule no. For pipe size above 42" and for non-standard schedules, piping material spec. (PMS), relevant pipe/fitting/valves vendor catalogues will be used for entering outside diameter, pipe thickness and weigh.
- Actual density shall be entered as per Line list.
- Insulation thickness shall be entered as per the line list.

### 11.2 CAESARII CONFIGURATION FILE AND UNIT FILES

- SI units will be followed for this project.
- The load combination cases is also attached in Appendix C

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نسخه	سریال	نوع مدرک	رشته	تسهیلات	صادر کننده	بسته کاری	پروژه																			
D01	0012	SP	PI	000	PEDCO	GNRAL	BK																			

## APPENDIX A “STRESS ANALYSIS LEVEL REQUIREMENTS”

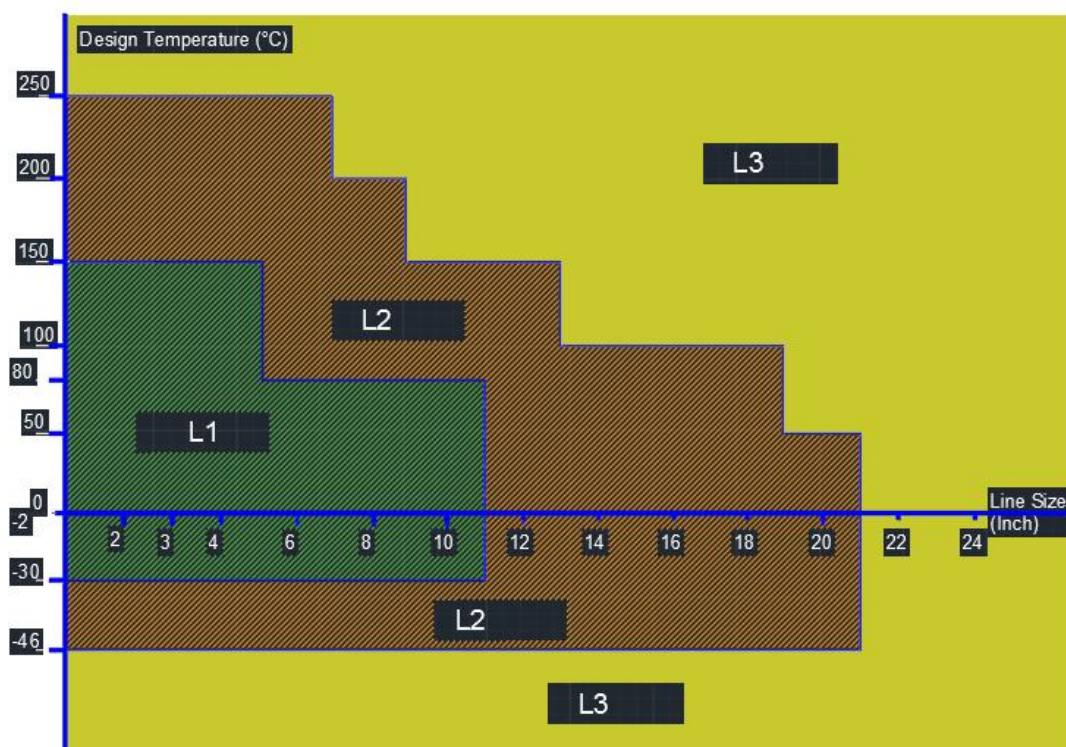




FIG # 1



 NISOC	<p>نگهداشت و افزایش تولید میدان نفتی بینک</p> <p>سطح الارض و ابنیه تحت الارض</p> <p>عمومی و مشترک</p>																	
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	پروژه		بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه									
BK	GNRAL	PEDCO	000	PI	SP	0012	D01											

Connection type		Pipe Size	Design Temperature ( ° C )								
			Below -	-46	0	50	85	100	150	250	above
1	Rotating machine ( Pump/ Compressor / Turbine ...) or sensitive equipment (e.g plate type heat exchanger , cold box, thin wall vessel with THK<5mm...)	$\phi \leq 4"$			"B" Grade						
		$\phi > 4"$			"B" Grade				"C" Grade		
2	Reciprocating machine (Pump & Compressor)	$\phi \leq 4"$			"B" Grade						
		$\phi > 4"$			"B" Grade			"C" Grade			
3	Expansion joint / Spring / Snubber	$\phi > 2"$			"B" Grade			"C" Grade			
4	Lines connected to fired heater / furnace / steam generator	$\phi \leq 4"$			"B" Grade						
		$\phi > 4"$			"B" Grade				"C" Grade		
5	Cryogenic (operating temperature)	$\phi > 2"$	"C" Grade								
6	High pressure with piping class $\geq 900$ Lbs	$4" \leq \phi \leq 8"$							"B" Grade		
		$\phi \geq 10"$			"B" Grade				"C" Grade		
7	Relief lines "To" and "From" PSV or rupture disc with up stream rating $\geq 300$ Lbs	$\phi \geq 3"$			"B" Grade			"C" Grade			
8	Air cooler	$\phi \leq 4"$			"B" Grade						
		$\phi > 4"$			"C" Grade						
9	Jacketed piping (Jacket size)	$\phi \geq 2"$			"B" Grade				"C" Grade		
10	Lines in "M" fluid service	$\phi \geq 2"$			"B" Grade				"C" Grade		
11	Non-ferrous material	$\phi \geq 4"$			"B" Grade				"C" Grade		
12	Non-metallic (above ground - note-1)	$\phi > 10"$			"B" Grade					"C" Grade	
13	Non-metallic (Buried - note-1)	$\phi > 14"$			"B" Grade				"C" Grade		



FIG # 2

Note:

1- By vendor

2-For GRE/GRVE/GRP/HDPE items, the SUPPLIER shall perform the formal computer analysis based on material properties and allowable stress values and other criteria of relevant product of SUPPLIER.

3- For specifying each line's criticality level ,Fig#1 (This chart comprises the lines connected to vessels including exchangers, reactors, drums, towers, filters, tanks, flare stack, silencers and lines which are not included in Fig#2 ) shall be used.

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پروژه	بسته کاری	صادر کننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه																			
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## APPENDIX B “STRESS ANALYSIS REPORTS”

The CAESARII Output generally includes the following terms and shall be officially issued for all level 3 pipes.

- Input Listing Report, including:
  - Element description, Bend Elements, Rigid Elements, Material ID.
  - Restraints, Uniform Loads, Allowable Stress, SIF's & Tee's.
  - Input Units, Setup File Parameters, Execution Control Parameters, Coordinate Report.
- Restraint-Displacement Summary Report
- Stress Summary Report
- Flange Leakage Table (if any)
- Nozzle load check
- Sketch

Note 1:

The special items such as spring, expansion joint, rigid-strut and snubber data sheets shall be prepared as per Stress Analysis requirements and shall be separately issued.



Note 2:

For Uniformity of work in direction, -X should consider as Plant North, +Y should consider vertical up direction.

## APPENDIX C "LOAD COMBINATION CASES" (ADD.)

SL.NO.	Combinations	Case	Remarks
1	WW+HP	HYD	HYDRO TEST
2	W+T1+P1	OPE	DESIGN
3	W+T2+P1	OPE	OPE.



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	BK	GNRAL	PEDCO	000	PI	SP	0012		D01

4	W+T2+P1+U1	OPE	EARTHQUAKE(N/S)
5	W+T2+P1+U2	OPE	EARTHQUAKE(E/W)
6	W+T2+P1+WIN1	OPE	WIND(N)
7	W+T2+P1+WIN2	OPE	WIND(S)
8	W+T2+P1+WIN3	OPE	WIND(W)
9	W+T2+P1+WIN4	OPE	WIND(E)
10	W+T2+P1+F1	OPE	PSV REACTION FORCE
11	W+P1	SUS	SUSTAINED
12	L4-L3	OCC	ALG
13	L5-L3	OCC	ALG
14	L6-L3	OCC	ALG
15	L7-L3	OCC	ALG
16	L8-L3	OCC	ALG
17	L9-L3	OCC	ALG
18	L10-L3	OCC	ALG
19	L11+L12	OCC	SCA
20	L11+L13	OCC	SCA
21	L11+L14	OCC	SCA
22	L11+L15	OCC	SCA
23	L11+L16	OCC	SCA
24	L11+L17	OCC	SCA
25	L11+L18	OCC	SCA
26	L2-L11	EXP	EXPANSION1 (ALG)
27	L3-L11	EXP	EXPANSION2 (ALG)

#### Designations

W: weight with content

WW: hydro weight

P1: design pressure

HP: hydro pressure

T1: Design Temperature

T2: Ope. temperature

U1: seismic coefficient in N/S direction

U2: seismic coefficient in E/W direction

WIN1: wind pressure in N direction

WIN2: wind pressure in S direction

WIN3: wind pressure in W direction

WIN4: wind pressure in E direction

F1=force

ALG: algebraic

ABS: absolute

SCA: scalar

In addition to the above, WNC (weight with no content) may be added with P1 at appropriate case.