12 Fire Protection

12.1 Overview

The project is a 50/50 joint venture, SORESCO S.A., between China National Petroleum Corporation International Ltd. (CNPCI) and Refinadora Costarricense de Petroleo, S.A. (RECOPE S.A.). SORESCO will implement an expansion project of the MOIN Refinery from 1,000KTA (25,000BPSD) to 3,000KTA (60,000BPSD) to meet the domestic demand for oil products.

The project mainly consists of the 2# atmospheric distillation unit (ADU), 2# vacuum distillation unit (VDU), naphtha hydrotreating unit (NHT), continuous catalytic reforming unit (CCR), delayed coking unit (De-coker), diesel hydrofining unit (DHF), VGO hydrocracking unit, H_2 production unit, isomerization and dry gas/LPG treatment unit, as well as the auxiliary facilities and utilities.

12.1.1 Fire Hazard Analysis

The fire hazard analysis of units is conducted according to the specifications, production process characteristics and the functions of related ancillary facilities, and the findings are indicated in the tables below.

Table12.1-1 Fire Hazards in Process Units

No.	Unit Description	Unit capacity, kt/a	Fire hazard classification
1	2# ADU	2,000	A
2	2# VDU	1,500	A
3	NHT	550	A
4	CCR	500	A
5	De-coker	700	A
6	DHF	1,300	A
7	VGO Hydrocracking Unit	900	A
8	H_2 Production Unit	25	A
9	Sulfur Recovery Unit	26	A
10	Dry Gas/LPG Treatment Unit	150	A
11	Isomerization	150	A

Table12.1-2 Storage Tank Farm Fire Hazards

No.	Tank description	Medium	Tank capacity, m^3	Q'ty, pc	Tank type	Fire hazard classification	Remarks
1	Crude Storage Tank	Crude	50000	7	External Floating Roof Tank	I-B	
2	Feedstock Storage Tanks	Ethanol	2000	2	Internal Floating Roof Tank	I-B	
3		1# Atmospheric Kerosene	1000	2	Internal Floating Roof Tank	II-A	To kerosene hydrogenation section
4		1# Atmospheric Residue	5000	1	stationary Roof Tank	III-B	To VDU
5		1# Atmospheric Naphtha	4000	1	Internal Floating Roof Tank	I-B	To NHT
6		1# Atmospheric Diesel	5000	1	Dome Roof Tank	II-B	To diesel hydrogenation section
7		2# Atmospheric Kerosene	1000	2	Internal Floating Roof Tank	II-A	To DHF
8		2# Atmospheric Residue	5000	3	Stationary Roof Tank	III-B	To VDU
9		2# Atmospheric Naphtha	4000	1	Internal Floating Roof Tank	I-B	To NHT
10		2# Atmospheric Diesel	5000	1	stationary Roof Tank	II-B	To diesel hydrogenation section
11		Vacuum VGO	5000	2	stationary Roof Tank	III-B	To hydrocracking unit
12		Vacuum Residue	5000	2	stationary Roof Tank	III-B	To coking section
13		Coker naphtha	1000	2	Internal Floating Roof Tank	I-B	To diesel hydrogenation section
14		Coker Gas Oil	2000	2	stationary Roof Tank	II-B	To diesel hydrogenation section
15		Coker VGO	1000	2	stationary Roof Tank	III-B	To hydrocracking unit
16		Heavy naphtha from hydrocracking	1000	2	Internal Floating Roof Tank	I-B	To CCR
17		Light naphtha from NHT	1000	2	Internal Floating Roof Tank	I-B	To isomerization unit
18		Heavy naphtha from NHT	3000	2	Internal Floating Roof Tank	I-B	To CCR
19		Naphtha from NHT	1000	2	Internal Floating Roof Tank	I-B	To NHT

No.	Tank description	Medium	Tank capacity, m^3	Q'ty, pc	Tank type	Fire hazard classification	Remarks
20		Light slop tank	2000	2	Internal Floating Roof Tank	III-A	
21		Product gasoline	2000	2	Internal Floating Roof Tank	I-B	
22		Light naphtha from NHT	1000	6	Internal Floating Roof Tank	I-B	
23		Heavy naphtha from NHT	1000	2	Internal Floating Roof Tank	I-B	
24		Isomerized oil	1000	2	Internal Floating Roof Tank	I-B	
25		Reformate	2000	2	Internal Floating Roof Tank	I-B	
26		Aviation kerosene	2000	2	Internal Floating Roof Tank	II-A	
27		Aviation kerosene	1000	3	Internal Floating Roof Tank	II-A	To DHF Unit
28		Aviation kerosene from hydrocracking	1000	2	Internal Floating Roof Tank	II-A	
29		Product diesel	10000	2	Dome Roof Tank	II -B	
30		Diesel from hydrocracking	5000	3	Dome Roof Tank	II-B	
31		Diesel from diesel hydrogenation	5000	2	Dome Roof Tank	II-B	
32		Fuel oil	500	2	Dome Roof Tank	II-A	
33		Heavy sump oil	3000	2	Dome Roof Tank	III-B	
34		Product LPG	2000	2	Dome Roof Tank	I-A	

Table12.1-3 Utilities Fire Hazards

No.	Unit Description	Functions	Fire hazard classification
1	Raw Water Treatment Plant (Water Supply Pump Station)	Plant-wide water treatment	E
1	CCW	Process/fire pumps	E
2	DM Water Station (including Condensate Polishing Station)	Circulating cooling water treatment	E
3	WWT	Circulating cooling water treatment	E

No.	Unit Description	Functions	Fire hazard classification
4	Water Supply/Drainage Pipeline System	Process/sanitary water treatment	D

Table12.1-4 Fire Hazards from Process & Service Facilities

No.	Unit Description	Fire hazard classification
1	Mechanical, Electrical and Instrument Workshop	E
2	Central Lab	C
	Environment Monitoring Station	
3	Administration Building	E
4	Staff Living Quarters	E
5	Chemical Warehouse	A

Table12.1-5 Properties of Main Inflammable and Explosive Materials

Material description	Explosion limits, v%	Flash point, ℃	Spontaneous ignition point, ℃	Explosive hazard classification		Fire hazard class
				Group	Class	
Crude oil	1.1～8.7	-6.67～32.2	350	T3	ⅡA	I-B
Dry gas	1.0～1.5	<～66	650～750	T1	A	A
LPG	3～13	<～68	430～446	-	-	I- A
Naphtha	1.2～6.0	36～177	480～510	T3	A	I-B
Gasoline	1.1～5.9	<～20	255～530	T3	A	I-B
Diesel	1.5～4.5	50～90	350～380	T3	IIA	III-A
Kerosene	0.6～	<45	223～290	T3	ⅡA	II-A
LPG	2.25～9.65	<-70	426	T2	ⅡA	I-A
Residual oil	1.2～6.0	50～158	300～350	T3	ⅡA	C
H_2	4.0～75.6	4.1～74.2	570	T1	IIC	A
H_2S	4.3～45	4.3～45.5	246	T3	IIB	A
N_2	16～25	15～25	650	T1	ⅡA	B
SO_2	-	-	-	T1	A	-
S	-	>180	232	T12	-	B

12.1.2 Firefighting System and Policy

(1) To observe the principle of the “Prevention First and Combining Prevention with Firefighting to Minimize Fire Damages and Ensure Personal and Property Safety.”

Strictly implement relevant codes for fire protection design and take proper precautions against fire to prevent and mitigate fire damages;

(2) To select disaster resistance and fire prevention technologies; to introduce advanced and proven disaster resistance and prevention technologies to provide reliable facilities, advanced technologies, rational engineering economics and practical operability;

(3) To determine firefighting facilities based on such factors as plant operation capacity, fire hazards and available surrounding combined efforts to extinguish fires; and

(4) To select a fire protection system with combined private fire brigades and voluntary fire brigades; to provide necessary emergency firefighting facilities for posts in support of the project.

12.2 Configuration of Firefighting Facilities

As shown in the following table, the main firefighting facilities will be located in each of plant spaces.

Table12.2-1 Main Firefighting Facilities for Plant Areas

No.	Unit Description	Capacity，kta	Fire hydrant	Fire monitor	Water spray fixed system	Fire extinguisher	Foam fire extinguishing system
1	2# ADU	2,000	√	√	√	√	
2	2# VDU	1,500	√	√	√	√	
3	NHT	550	√	√	√	√	
4	CCR	500	√	√	√	√	
5	De-coker	700	√	√	√	√	
6	DHF	1300	√	√	√	√	
7	VGO Hydrocracking Unit	900	√	√	√	√	
8	H2 Production Unit	25	√	√	√	√	
9	SRU	26	√	√	√	√	
10	Dry Gas/LPG Treatment Unit	150	√	√	√	√	
11	Isomerization	150	√	√	√	√	
12	Tank farm	-	√	√	√	√	√

12.2.2 Firewater Supply System

12.2.2.1 Brief Description of the Existing Firewater System

The existing firefighting facilities are available in service, including fire hydrants, fire monitors, stationary sprinklers & cooling systems, low-expansion foam extinguishing systems,

etc.

The max firewater feed rate to existing refinery LPG spheres is 2,270 m^3/h; the max firewater feed rate to process plant areas is 1,360m^3/h.

Table12.2-2 Existing Refinery Firewater Feed Rates

No.	Unit Description	Firewater feed rate, m^3/h
1	Firewater feed rate to existing refinery LPG spheres	2270
2	Firewater feed rate to existing refinery firefighting system	1360

12.2.2.2 Firewater Consumption

For the upgraded MOIN refinery, it is assumed that two fires occur at the same time, one would take place in the plant area, where the firewater consumption is the maximum, the other would take place in the auxiliary production facilities. Firewater consumptions will be designed based on the water feed rates to firefighting facilities located in areas. The maximum firewater consumption may occur in the water spray fixed system in the tank farm. A design margin at 200m^3/h is considered on the basis of the total firewater consumption by fixed foam fire extinguishing systems, fire monitors and fire hydrants. Considering that the max firewater consumption by the tank farm is at 3,300m^3/h, plus the 180m^3/h firewater consumed by auxiliary facilities, the firewater demand for the project is designed at 3,480m^3/h. The inflow pressure is considered not less than 0.8MPa(G), this represents an extreme worst case, assuming a 6h fire duration.

12.2.2.3 Firewater Sources

A HP firewater pumping station is design for supporting the project, where the firewater is taken from the Moin River to the HP firewater systems for the new process units. The HP firewater pump station is designed to have a supply flow rate at 3,480 m3/h for a fire lasting for 6 hours.

The fire pumping station is provided with a fire electric fire pump with a design flow rate of 1,160m^3/h & a lift of 100m. Three diesel pumps are installed, i.e., the two in operation and the other standby with a design flow rate of 1,160m^3/h per set and a lift of 100m. In case of a fire, the related firefighting pipe network has a rapid pressure drop, and the HP electric fire pumps activates. In case of a failure on the electric fire pump or increased firewater flow, the diesel pumps will activate.

Two jockey pumps (1 operating and 1 spare) will be installed with a design flow rate of 50m^3/h and a lift of 120m.

12.2.2.4 Firewater System

A firewater system consists of a firewater supply system and indoor fire hydrants,

outdoor hydrants, stationary hand-operated water guns, and fixed water spray systems. The firewater is designed to cool the affected equipment and areas, where may be exposed to the thermal radiation to protect escape exit, and to control & extinguish the fire partially.

12.2.2.5 Foam Fire Extinguishing System

A stationary low expansion foam fire extinguishing system is installed in the crude tank farm. A stationary low expansion foam fire extinguishing system will be provided in the tank farm. A loop foam pipe network will be located around the tank farm. The foam pipe network will be equipped with a number of outdoor above-ground foam hydrants,with hose cabinets for rapid fire extinguishing.

A balancing pressure foam proportioner is selected for the foam fire extinguishing system of the storage tanks. The balancing pressure foam proportioner will be provided with a $5m^3$ foam concentrate storage tank to store the 3% aqueous film-form foam. The mixed foam liquid flow rate is about 64L/s.

Portable foam fire extinguishing system should be installed in the plant if pool fire may happen.

12.2.3 Steam Fire Smothering System

A fixed extinguishing system or semi-fixed extinguishing system may be provided in a closed pump room or a compressor room; however, where the accident may occur, steam must not be used for extinguishing.

12.2.4 Gas Fire Extinguishing System

An inergen gas fire extinguishing system is provided in the control room.

12.2.5 Fire Extinguishers

Sufficient portable and wheeled fire extinguishers will be provided in the plant area; portable carbon dioxide fire extinguishers will be provided in control rooms and substations in response to any possible fires.

12.2.6 Detection and Preaction Systems

Combustible gas detection annunciators will be provided in sites where combustible gases may build up. Portable poisonous gas monitors will be provided in the places and around the equipment where toxic gases may exist and alarm signal is sent to the master control room.

Flammable gas detection system (FGDS for short) will be provided independent of the process control system (DCS) and the safety instrumented system (SIS).

12.2.7 Project-wide Fire Alarm System

An automatic fire alarm system will be provided in the plant area for early monitoring, forewarning, equipment detection, display, alarm, operating condition, accident record, maintenance, and access control.

This system consists of the general alarm panel (fire station), fire alarm control display panel (CCR), sector fire alarm control display panel (in buildings or rack rooms with fire linkage systems), sector fire alarm panel (in buildings or rack rooms without fire linkage systems), smoke detectors, heat sensitive detectors, manual pull station and fire emergency paging system. The front end alarm devices are designed to use the address code. Flame retardant cables will be used as wiring cables of the fire alarm system.

Alarm signals from such terminal equipments as detectors and alarm buttons of units in the plant area, tank farms and buildings are sent to the local sector fire alarm control panel or sector fire alarm panel. Such controlled equipments as the solenoid valves of preaction valves and firefighting equipments to the smoke exhaust fans and vent ducts shall be incorporated into the local sector alarm panels, where the signals of alarm, control and the operating conditions of firefighting equipments are sent from the site-wide fire alarm control platform to the fire department's control room and CCR. All controllers for the firefighting equipment shall control the functions of that equipment locally.

Sector fire alarm control panels or sector fire alarm panels will give signals to fire alarm control display panels in CCR. The communication lines between fire alarm control display panels, sector fire alarm control panels and sector fire alarm panels will be routed along bridges or laid underground. Sector fire alarm control panels will be installed in attended areas.

The control room shall be provided with automatically-actuated gas extinguishing systems. Bus fire detectors will be provided in CCR, substations, laboratory(s), corridors, passways, offices, halls, air conditioning facilities, power distribution rooms, maintenance shops and other areas for protection purpose. Manual alarm buttons shall be installed at the main exits at each floor of the buildings, the walk-around access of plant area and by the waysides around tank farm. Explosion-proof flame detectors will be provided for hot oil pumps in the plant area. Resettable thermal static cables or thermometric cables shall be installed along the cable interlayers. Such devices as optical fiber thermoscope and fiber grating will be installed on the crude storage tanks.

The heat sensitive detectors, smoke detectors and manual pull stations shall be of the intrinsic safety explosion-proof type or flameproof type. Low contributed parameter cables will be used between intrinsically-safe equipment and safety barrier.

Sirens or audible-visual annunciators provided for the process units may be linked with fire alarm panels in the area to give audible alarms. Audible-visual annunciators are provided at main walk-around accesses, where the installation heights will be determined accordingly. Other warning facilities will be selected according to environmental requirements to be

appropriate to environmental requirements.

Automatic fire alarm systems will be interconnected with CCTV systems, DCS and paging system, where the CCTV's linkage interfaces will be located in CCR. Communication interfaces with DCS will be located on monitoring devices or sector fire alarm control panels or sector fire alarm panels in tank farm.

12.3 Fire Station

12.3.1 Existing local firefighting facilities

Two existing fire engines are provided for the fire station at the project site; however, they have been used for nearly 20 years. Therefore, there is considerable concern, i.e., corroded engines and non-workable foam tenders.

12.3.2 Fire Station

In view of existing fire station, and the appropriate firefighting facilities to be installed at the battery limits, more fire vehicles shall be provided for the project. Three new fire engines, four parking spaces are designed for the fire station, one of which will be provided with a service pit. They are provided with necessary firefighting equipments, such as PPE for firefighters, fire forcible entry tools, means of communications and so forth.

Table12.3-1 Fire Engines

No	Vehicle description	Q'ty, pc	Specifications
1	Elevating platform fire truck/water tower fire truck	1	Nominal operational height: ＞28m Hopper load: 0.4 t Fire monitor capacity: 100L/s (50L/s x2) Warning devices, communications facilities, lighting fixtures and control panel to be provided in the basket
2	Heavy-duty water tanker-foam universal fire truck	2	Foaming capacity: 6,000L; Water holding capacity: 12,000L Mixed foam flow rate: 60 L/s Fire monitor capacities: water monitor: 80 L/s; foam monitor: 48 L/s Fire pump capacities: 70L/s @ 1.0MPa; 35L/s @ 2.0MPa
3	Total	3	

12.4 Investment in Firefighting Facilities

The investment in the firefighting facilities for the project will be used for the following purpose:

A firewater system consists of firewater pump houses, firewater storage tanks, fire pumps, jockey pumps, HP firewater pipes, valves and valve wells, indoor/outdoor ground type fire hydrants, fire water monitors and box type hydrants, firewater supply risers, sprinkler

systems cooling LPG storage tanks, automatic water sprinkler system and so on;

The foam fire extinguishing system mainly includes a separate foam station, a balancing pressure foam proportioner, ARFFF foam concentrate, foam mixture pipes and valves, foam hydrants and foam generators, and so on.

The Inergen gas fire extinguishing system mainly includes an inergen extinguishant cylinder battery, a fire detection system, system initrializaion control system, gas extinguishing system piping and gas nozzles.

Other fire protection facilities mainly include steam smoothering lines, semi-fixed steam connection, portable and wheeled dry powder fire extinguishers and portable carbon dioxide fire extinguishers;

Fire alarm and combustible gas alarm systems mainly include the manual fire alarm system, automatic fire detecting devices for temperature-sensitive cables, fire detectors, combustible gas detectors, their connecting cables, fire and combustible gas alarm display and control panels.

Refer to Chapter 17 - Economics Evaluation - for the specific costs of firefighting facilities.

12.5 Design Regulations, Codes and Standards for Fire Protection System

NFPA 1 Uniform Fire Code

NFPA 10 Standard for Portable Fire Extinguishers

NFPA 11 Standard for Low-, Medium-, and High-Expansion Foam

NFPA 13 Standard for the Installation of Sprinkler Systems

NFPA 15 Standard for Water Spray Fixed Systems for Fire Protection

NFPA 20 Standard for the Installation of Stationary Pumps for Fire Protection

NFPA 30 Flammable and Combustible Liquids Code

NFPA 101 Life Safety Code

NFPA 2001 Standard on Clean Agent Fire Extinguishing Systems

Please refer to relevant China fire protection codes and standards if necessary.