Fuel Operations After Natural Disasters

Experiences From The Industry

Effective Feb 2018

Edition 1st

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International Air Transport Association

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Fuel Services Department
International Air Transport Association
800 Place Victoria
P.O. Box 113
Montreal, Quebec
CANADA H4Z 1M1

Fuel Operations After Natural Disasters: Experiences From The Industry

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PART I. SCOPE

Natural disasters are impossible for anyone to reliably predict when and where it will happen. It is a fact that each country is making efforts to elucidate by using the latest technology and spending a lot of personnel and expenses to achieve its purpose. However, with the recent change by global warming, unexpected natural disasters are occurring in various countries.

In addition to natural disasters, in the event of a disaster, it is very important to maintain the airport's flight capability with regard to the region's reconstruction. Especially, in the event of a disaster, the lifeline of the occurrence area and its surrounding areas, such as, the transportation and energy supply will be cut off, so in such a case recovery measures using aircrafts will play a very important role.

In the event that the supply of energy is cut off, how to ensure the operation of the aircraft. For that purpose, we must establish a system that can release the fuel stored in the airport fuel storage facility to the aircraft as soon as possible. In the event of a disaster, I think that the airport facilities are affected as a matter of course. This is important to how we can restore functions quickly in such circumstances.

In particular, various criteria are set from the viewpoint of handling dangerous goods from airport fuel storage facility and aircraft fuelling system, and various safety confirmations must be promptly carried out to resume function. Although it is not easy to recover functions in the event of disasters due to the surrounding environment being confused, preparations for drills usual day and preparing response manuals for disaster occurrence are fundamental in order to recover as soon as possible. It goes without saying that cooperation of suppliers and cooperation of government agencies are important for maintaining aviation fuel supply at the airport.

The IATA Fuel Forum was held at Cancun, Mexico on November 3, 2015, and the damage and reconstruction situation of Sendai Airport due to a major earthquake and tsunami in Japan, the damage of Bangkok, Don Muang Airport due to major flood damage in Thailand and the subsequent reconstruction were reported. These disasters are of a size exceeding imagination and reconstruction was not easy either. However, there is no guarantee that such disasters will not occur in the future, IATA TFG decided to put together a manual explaining how the fuel facilities were handled during the earthquakes and tsunami events. The flight and fuel operations played a major role in the area of reconstruction described earlier. In addition to the two cases that occurred in recent years, we added the experience of the earthquake in Mexico City that occurred on September 19, 1985, and with this information, we were able to compile this manual.

It can be said that these experiences include how to prepare for unpredictable natural disasters and how to quickly recover the aviation fuel supply system at the airport in case of a disaster. It can be said that it is a great reference to how to prepare for the future based on such an unprecedented experience. This manual provides guidance to airports where the occurrence of natural disasters is concerned and it will be a reference for building new facility requirements for natural disasters.

We highly appreciate the stakeholders who cooperated in issuing the Fuel Operations after Natural Disasters: Experiences from the industry.

Yukio Mashimoto
Manager
Airport Centre, All Nippon Airways Co., Ltd.

PART II — EARTHQUAKE EXPERIENCES;

EXPERIENCE IN MEXICO HANDLING NATURAL DISASTERS CAUSED BY EARTHQUAKES AND HURRICANES.

Introduction

Mexico is a country on the American continent adjacent to the United States in the north, and with Guatemala and Belize in the south, besides having a long coastline bordering the Pacific Ocean in the west and the Gulf of Mexico and Caribbean Sea in the east.

Territory of Mexico

Figure 1-Source: INEGI. Marco Geo-estadístico Nacional 2010.

Due to its territorial extension (almost 2 million km²), Mexico has 1,500 aerodromes and 76 airports that give attention to more than 120 million passengers nationally and internationally.

Mexico has been impacted by various natural events (earthquakes and hurricanes) that caused important tragedies in a short period of time (5 years or less).

This section of the document will explain the most significant events, such as earthquakes and hurricanes that affected the aviation fuel services, triggering a disruption in the fuel airports operations. Additionally, it will reflect on the experiences that has brought the high level industry's attention, before, during and after the events. Concluding with the recovery of operations which minimized the impacts.

Significant events covered:

- Earthquakes generated in the period 2010-2016.
- Impact of hurricanes (2013-2016), highlighting Ingrid, Manuel and Odile.

EARTHQUAKES IN MEXICO

Introduction

The Mexican Republic is located in one of the most seismically active regions in the world. It's nested within the area known as the Circumpacific Belt where the largest seismic activity on the planet is concentrated.

The high seismicity in the country, is mainly due to the interaction between the plates of North America, Cocos, the Pacific, the Rivera and the Caribbean, as well as to local faults that run along several states, although the latter is less dangerous. The North American Plate separates from the Pacific but rubs against the Caribbean Plate and crashes against those of Rivera and Cocos, hence the events of earthquakes.

Chiapas, Guerrero, Oaxaca, Michoacán, Colima and Jalisco are the states with the highest seismicity in the Mexican Republic. It is due to the erosions between the oceanic plates of Cocos and Rivera that connects with those of North America and the Caribbean on the Pacific coast in front of these States. The states of Veracruz, Tlaxcala, Morelos, Puebla, Nuevo Leon, Sonora, Baja California, Baja California Sur and Mexico City are also affected by the same erosions.

Seismic Regions in Mexico

For purposes of anti-seismic mapping, the Mexican Republic was divided into four seismic zones, using the country's earthquake records since the beginning of the century.

- Zone A is an area where there are no historical records of earthquakes. No earthquakes have been reported in the last 80 years. The soil accelerations are greater than 10% of the acceleration of gravity where shocks are not expected.

- Zones B and C are intermediate zones, where earthquakes are recorded with less frequency, or are areas affected by high accelerations, but not more than 70% of the acceleration of the soil.

- Zone D is an area where great historical earthquakes have been reported. The earthquakes occurrences are very frequent, and the soil accelerations can exceed 70% of the acceleration of gravity

Seismic Zones in Mexico

Figure 2-Manual de diseño de Obras Civiles (Diseño por Sismo) CFE

The impact of earthquakes in Mexico has been of high importance. The most significant one, occurred on September 19, 1985, when Mexico City was devastated by an earthquake measuring 8.1 on the Richter scale.

While the documented and photographic collection of the earthquake in the area of fuels is limited, it is also known of its repercussion to the foundation of the storage tanks, to the rupture of the underground fuel distribution network, as well as the impact on operational capability of the fuel service into plane.

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Below is a list of the tremors that have occurred in Mexico from 2010 to 2017, with a magnitude equal to or higher than 6° on the Richter scale.

Magnitud	Fecha y hora	Epicentro localización: latitud, longitudloc.: lat., long.	Profundidad
6	08/05/2016 02:33	13 km al SURESTE de PINOTEPA NACIONAL, OAX : 16.25°, -97.98°	35 km
6	27/04/2016 07:51	122 km al SUROESTE de HUIXTLA, CHIS : 14.35°, -93.26°	20 km
6	25/04/2016 02:07	131 km al SUROESTE de CD HIDALGO, CHIS : 14.26°, -93.29°	16 km
6.1	15/04/2016 09:11	124 km al SUR de CD HIDALGO, CHIS : 13.56°, -92.28°	12 km
6.5	21/01/2016 12:06	277 km al OESTE de CIHUATLAN, JAL : 18.79°, -107.15°	10 km
6.6	17/12/2015 13:49	37 km al SUR de TONALA, CHIS : 15.76°, -93.7°	90 km
6.7	13/09/2015 03:14	105 km al SUROESTE de LOS MOCHIS, SIN : 24.96°, -109.49°	10 km
6.3	22/02/2015 08:23	233 km al SUROESTE de CIHUATLAN, JAL : 18.65°, -106.69°	16 km
6.1	07/10/2014 21:40	145 km al SUROESTE de ELDORADO, SIN : 23.23°, -108.16°	10 km
6.4	29/07/2014 05:46	46 km al SUROESTE de ISLA, VER : 17.7°, -95.63°	117 km
6.9	07/07/2014 06:23	47 km al SUROESTE de TAPACHULA, CHIS : 14.75°, -92.63°	60 km
6.2	31/05/2014 06:53	284 km al SUROESTE de PUERTO VALLARTA, JAL : 18.99°, -107.33°	10 km
6.1	10/05/2014 02:36	38 km al SUROESTE de TECPAN, GRO : 17.06°, -100.95°	12 km
6.4	08/05/2014 12:00	28 km al SUROESTE de TECPAN, GRO : 17.11°, -100.87°	17 km
7.2	18/04/2014 09:27	40 km al SUR de PETATLAN, GRO : 17.18°, -101.19°	10 km
6.3	19/10/2013 12:54	89 km al ESTE de LORETO, BCS : 26.09°, -110.46°	14 km
6.1	06/09/2013 19:13	39 km al SUROESTE de CD HIDALGO, CHIS : 14.34°, -92.26°	69 km
6	21/08/2013 07:38	18 km al OESTE de SAN MARCOS, GRO : 16.79°, -99.56°	20 km
6.2	25/03/2013 17:02	149 km al ESTE de CD HIDALGO, CHIS : 14.35°, -90.81°	198 km
6.1	15/11/2012 03:20	26 km al SURESTE de CD ALTAMIRANO, GRO: 18.17°, -100.52°	40 km
6.2	11/11/2012 16:15	76 km al SUROESTE de CD HIDALGO, CHIS : 14.06°, -92.48°	13 km
7.3	07/11/2012 10:35	68 km al SUROESTE de CD HIDALGO, CHIS : 14.08°, -92.32°	16 km
6	25/09/2012 18:45	70 km al NORTE de LA PAZ, BCS : 24.76°, -110.17°	15 km
6.1	01/05/2012 17:43	126 km al SUROESTE de CD HIDALGO, CHIS : 14.11°, -93.16°	40 km
6.8	12/04/2012 02:15	109 km al NORESTE de GUERRERO NEGRO, BCS : 28.78°, -113.43°	10 km
6	12/04/2012 02:05	111 km al NORESTE de GUERRERO NEGRO, BCS : 28.79°, -113.43°	15 km
6.4	11/04/2012 17:55	79 km al OESTE de LA MIRA, MICH: 17.9°, -103.06°	16 km
6	02/04/2012 12:36	45 km al OESTE de PINOTEPA NACIONAL, OAX: 16.27°, -98.47°	10 km
7.4	20/03/2012 12:02	29 km al SUR de OMETEPEC, GRO : 16.251°, -98.521°	16 km
6	21/01/2012 12:47	86 km al SUROESTE de MAPASTEPEC, CHIS : 14.74°, -93.24°	16 km
6.5	10/12/2011 19:47	53 km al NOROESTE de ZUMPANGO DEL RIO, GRO : 17.84°, -99.98°	58 km
6	01/11/2011 06:31	348 km al SUR de CABO SAN LUCAS, BCS : 19.79°, -109.35°	5 km
6.7	07/04/2011 08:11	83 km al SUROESTE de LAS CHOAPAS, VER: 17.2°, -94.34°	167 km
6	25/02/2011 07:07	32 km al SUROESTE de SAYULA DE ALEMAN, VER : 17.73°, -95.21°	135 km
6.5	21/10/2010 12:53	103 km al NORESTE de LA PAZ, BCS : 24.62°, -109.43°	8 km
6.1	23/08/2010 21:11	295 km al SUROESTE de CIHUATLAN, JAL : 18.44°, -107.23°	10 km
6	30/06/2010 02:22	13 km al SUR de PINOTEPA NACIONAL, OAX: 16.22°, -98.03°	8 km
7.2	04/04/2010 17:40	18 km al SURESTE de MEXICALI, BC : 32.54°, -115.36°	10 km

HURRICANES "MANUEL" FROM THE PACIFIC OCEAN AND "INGRID" FROM THE ATLANTIC OCEAN (2013)

On September 13, 2013, the tropical depression No. 13 of the Pacific Ocean was formed and became the tropical storm knowns as "Manuel". On September 15, at approximately 2 pm, the tropical storm "Manuel" touched down on the City of Manzanillo, Colima with maximum sustained winds of 100 km/hr and gusts of 130 km/hr. Which landed at 4 pm at 3 km to the northwest of the population of La Lima, and 20 km to the north of Manzanillo.

On September 16, the tropical depression "Manuel" was located 25 km northeast of Tomatlán, Jalisco, moving towards the northwest at 13 km/hr, very close to weakening at low pressure. At 4:00 o'clock on the same day, DT "Manuel" was again in the sea with a low pressure and sustained maximum winds of 45 km/hr and gusts of 65 km/hr. It is until September 19 that the intensity of the hurricane decreased and the conditions of this hurricane improved.

Trayectoria final del huracán "Manuel" del Océano Pacífico,
del 13 al 19 de septiembre del 2013

On September 12, 2013: Hurricane Ingrid, a tropical depression No. 10, was formed in the Atlantic Ocean. It started 150 km north-northwest of Chiltepec, Tabasco, with maximum sustained winds of 55 km/hr, 75 km/hr and westward shifts at 11 km/hr.

After reaching tropical storm force, "Ingrid" remained almost stationary from 13:00 to 22:00 o'clock on September 13 and resumed its trajectory. This time advancing towards the north-east, while increasing its strength gradually. On September 14, the storm reached 295 km east-northeast of Veracruz, Veracruz, with a maximum intensity winds of 120 km/hr with gusts Of 150 km/hr. Hurricane "Ingrid" continued its course towards the coast of Tamaulipas

One of the characteristics of Mexico, in terms of tropical cyclones, is the probability of simultaneous impact for both, the Pacific and Atlantic Ocean. The hurricane Manuel affected the Pacific side, south and west coast of Mexico. Whereas the hurricane, "Ingrid" strongly affected the coast of Veracruz and Tamaulipas by the side of the Gulf of Mexico, This situation did not occur since the year of 1958, where two Tropical storms in different watershed, simultaneously affected the country.

The "Ingrid" trajectory lasted 108 hours, during which time it covered an approximate distance of 1,400 km at an average speed of 13 km/hr.

Trayectoria final del huracán "Ingrid" del Océano Atlántico

Once the weather situation stabilized, ASA initiated actions to assess the damages caused at the Fuel Farms. In a general perspective, the infrastructure and equipment damages were low but the airport located in Acapulco had considerably damages caused by the flood.

Also, the fuel farm at that airport had floods, but with no high impact in its operation.

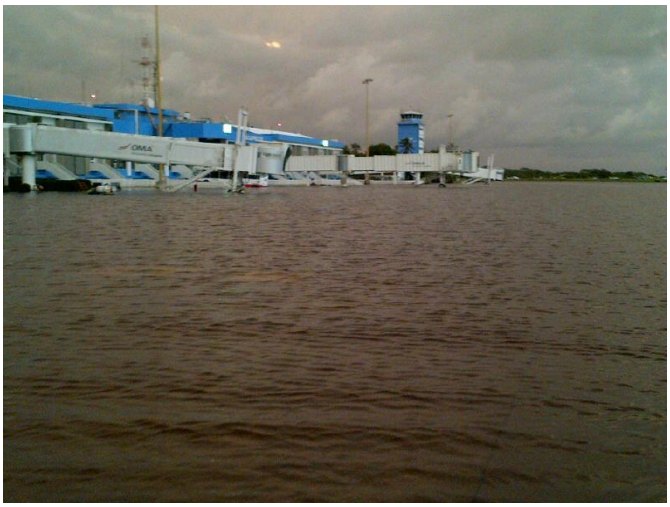

Figure 3-Flood, Acapulco Airport

Figure 4-Flood, Fuel Farm, Acapulco Airport

Figure 5-River overflow, Guerrero, near Acapulco Airport.

From September 17 until the 24, 2013 there were 667 thousand liters of fuel supplied through 573 operations in Acapulco (mostly helicopters), of which 75% went to normal aircraft.

In addition, ASA distributed almost 1 million liters in seven alternative supply points that were possible in the towns of Ciudad Altamirano, Chilpancingo, Tlapa, Zihuatanejo, Acapulco, Ometepec, Ayutla de los Libres.

Figure 6-Locations in the state of Guerrero, were jet fuel supply was needed.

In total, 1,500,000 liters of jet fuel were supplied. This is a region that normally sells about 35 thousand liters per day.

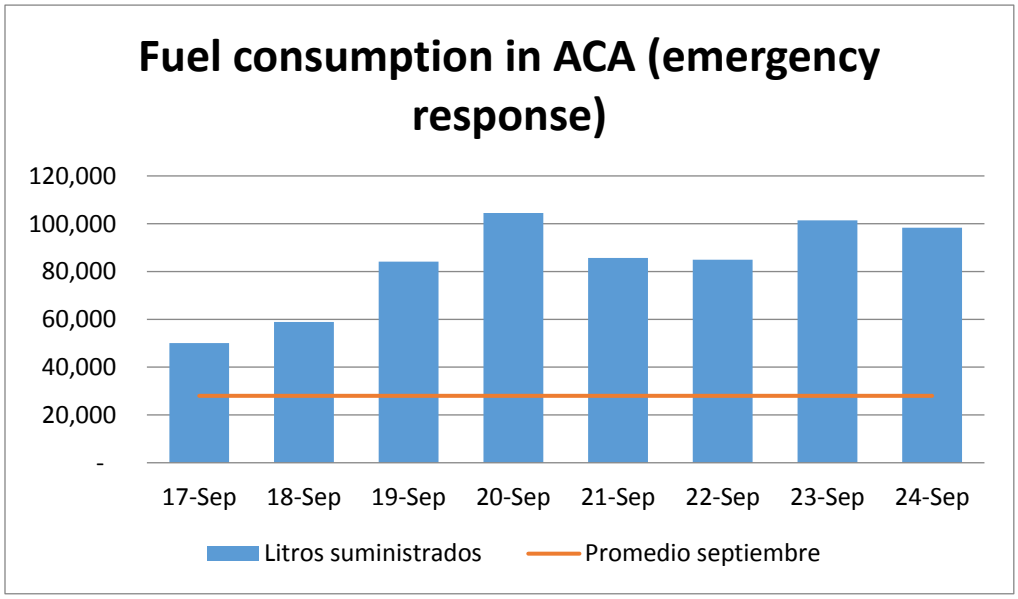

Figure 7-Fuel supply on September 16, 2013, after the passage of "Manuel" and "Ingrid" Hurricanes at Acapulco Airport, Guerrero

HURRICANE ODILE IN THE PACIFIC OCEAN (2014)

On September 10, at dawn, the tropical depression No. 15 of the season was formed in the Pacific Ocean, 385 km southwest of Acapulco, Guerrero, with maximum sustained winds of 55 km / h and 75 km / H, which quickly formed as Tropical Storm Odile.

Between September 11 and 13, this tropical storm continued to move northwest with sustained maximum winds of 85 mph with 100 km/hr spurts.

On September 13, "Odile" intensified its winds, forming a hurricane with maximum sustained winds of 120 km/hr and gust races of 150 km/h. The system continued to increase its strength and at 19:00 local time, when it was 275 km southwest of Manzanillo, Colima, It reached category II on the Saffir-Simpson hurricane scale with sustained maximum winds of 160 km/h to 185 km/h.

From midnight to the following noon of September 15, the back of the hurricane was crossing the coast, so the entire central zone of strong convection stretched over southern Baja California Sur. Tropical storm "Odile" lost strength between September 16 and 17 and weakened to a tropical storm.

Once the hurricane crossed the peninsula, the damages assessment work started.

Three airports were located in the zone where the hurricane crossed: San José Del Cabo (SJD), La Paz (LAP) and Loreto (LTO). All these airports underwent considerable damages where SJD suffered the most.

Due to the force of the impact, all communications in the area of the peninsula were lost, as well as the electric power supply, because all high voltage towers fell during the hurricane.

Fortunately, all of the personnel in the fuel farm and most of the personnel in the airport did not suffer any material damages at home, so they were able to support duties at the location.

The airport encountered serious damage in the area of passenger terminals as well as in the control tower and support equipment, however, the runway and airport platform were not demolished.

Figure 8-Damage in terminals, SJD Airport.

The fuel farm suffered minor loss in infrastructure, however the administration building was the most affected internally and the loading and unloading control equipment were also affected.

The area of tanks had minor impacts; nevertheless, the hydrants system suffered flooding and minor consequences by sand and wind.

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Figure 9-General view, SJD fuel farm, after the hit of the Hurricane.

Due to the impacts that occurred in the year 2013, an "air bridge" was generated to rescue the stranded tourists, who were mostly of foreigners.

To re-establish operations, ASA sent a team of electrical and electronic equipment maintenance specialists within the first 6 hours after the hurricane.

After assessing the damages and using the aid flights that were departing from Mexico City, food, personnel and equipment were sent to restore operations, restarting within the first 24 hours after the hurricane.

For the quality part, it was necessary to send a team of specialized personnel to evaluate the network of hydrants as well as possible contamination by water and solids (sand).

The communication was a major problem and due to the small availability of satellite telephones in the area, telephones were sent from Mexico City.

ASA supported the supply of fuel, from the San José del Cabo station as well as nearby and from Mexico City Airport (end of the bridge), providing more than 1.2 million liters in 243 Services during this period.

Damages from earthquakes

There is no record of severe consequences to the fuel farms caused by an earthquake in the last 19 years. Therefore, no evidence of damage is included.

The 1985 earthquake was a big event that caused considerable damage in all the Mexico City Area so the probability of occurrence is latent.

Figure 10-Damage in residential buildings, Mexico City, 1985

However, the response preparation to these natural events is constant. The following elements are reviewed:

- Civil protection plan,
- Disaster Recovery Plan by Federal Authorities and
- Operations Recovery Plan

Lessons Learned

During all events, whether earthquakes or hurricanes, the airports of Acapulco, Los Cabos, Mexico, as well as those associated with the earthquake zone in Oaxaca and Chiapas, were used as a center of operations for entities conducting search and rescue.

In the case of earthquakes, the airports served as a gateway for the collection and distribution of aid. In the case of hurricanes, the airports also served as the main gateway for transporting people, especially tourists, which was the main reason for prioritizing the restoring of the fuel supply operations.

The main problems were:

- Availability of resources: Although there were no major impact to their families or homes, it was necessary to send specialists from different areas to restore operations.
- Geographic distribution of operations: Not only helicopters needed to be organized to cover a wide area, but also vehicles had to be deployed to isolated areas, which did not have all-terrain capabilities to reach the point of assistance, specifically in the Guerrero State.
- Validation of fuel quality: The hydrant networks were damaged and had possibility of contamination by water and dirt. This justified the call for some dispatch quality specialists, whom were not trained to work in an emergency environment.
- Communications: Written and verbal communication were completely interrupted.
- Damages to the infrastructure: The electrical and electronic control components were affected. In order to restore the services, some of the damages required the total replacement of the equipment. Getting them during holidays (especially in the impact of hurricanes) proved to be a challenge.
- Coordination of activities with multiple authorities: Due to the severe extension of damages, the participation from the authorities were required. This caused tension when prioritizing the supply services to helicopters.

  Total suspension of the fuel supply were due to damages in the land communication routes.

Business Continuity Plan.

Due to the constant impacts in the years 2013 and 2014 by Hurricanes as well as the increase in the probability of major events in airports such as Mexico City and Cancun, which represent 60% of the total volume supplied nationwide, ASA decided to generate the Business Continuity Management System (BCMS), using the international standard ISO 22301 as a reference framework.

The main reason for using the ISO standard is that today, the operating procedures of the fuel farms and into-plane services are documented and certified under ISO 9001, thus facilitating their understanding and documentary integration, however, there are other references that can be used.

Considering the importance of an airport when responding to an emergency, the primary objective is to reestablish fuel service through refuels, taking into account the volumes of fuel and operations presented in previous situations.

The following table shows the main documents generated that compose the BCMS.

BUSINESS CONTINUITY MANAGEMENT SYSTEM AEROPUERTOS Y SERVICIOS AUXILIARES (ASA)

Document Code	Document Type	Document Name	Description
FTN-01-00	FORMAT	SWOT Matrix	Qualitative method that shows to the organization at which point it is in terms of strengths, weaknesses (internal), opportunities and threats (external)
FTN-02-00	FORMAT	Stakeholder Matrix	Document identifying stakeholder requirements.
-	PROCEDURE	Scope of the Business Continuity Management System	Scope of the Business Continuity Management System
PSN-02-00	PROCEDURE	Management of Risks and Opportunities	Losses and side effects are identified, analyzed and quantified
FTN-04-00	FORMAT	Matrix of Compliance with Business Continuity Objectives	Objectives defined by senior management to ensure business continuity.
PSN-03-00	PROCEDURE	Business Impact Analysis	Method for evaluating the impacts of the disruption of activities and determining priorities, continuity objectives and service recovery.
PSN-04-00	PROCEDURE	Business Continuity Strategy	Details how top management ensures compliance with the conditions to resume commercial activities for fuel supply in the event of a disruptive incident.
FTN-06-00	FORMAT	List of Activities for the Provision of Key Products and Services	List of Activities for the Provision of Key Products and Services
FTN-07-00	FORMAT	Recovery Time Objectives for Activities	Recovery times are established by taking different variables, such as the business impact analysis questionnaire.
FTN-08-00	FORMAT	Business Continuity Preparation Plan	Check list of the Business Continuity Preparation Plan.
FTN-09-00	FORMAT	Recovery Priorities for Activities	Defines the maximum tolerable periods of interruption (maximum acceptable interruptions) for each activity and establishes priorities accordingly.
PSN-05-00	PROCEDURE	Risk Management and Mitigation Measures	Establishes the method for risk management and mitigation measures as proactive measures that reduce the likelihood of disruption, interruption period and limit on the impact of disruption on processes
PSN-06-00	PROCEDURE	Business Continuity Plan	Describes how top management responds to a disruptive incident and continues or reestablishes its activities over a predetermined period of time.

Document Code	Document Type	Document Name	Description
PSN-07-00	PROCEDURE	Disaster Recovery Plan	Establishes the general procedures for recovering information technology infrastructure and services in the presence or effects of a disaster (generated by nature's own activity) or disruptive incident, within the recovery time objective (OTR).
FTN-14-00	FORMAT	Business Continuity Preparation Plan	Steps to follow to carry out the Business Continuity Preparation Plan.
PSN-09-00	PROCEDURE	Response to Incidents	Actions to protect people, environmental impact, infrastructure and continuity of service, as well as contain in case of a disaster or disruptive incident; Seeking to minimize possible harm to the business.
FTN-18-00	FORMAT	Activity Recovery Strategy	Define the recovery time goal for this activity in Hours / Days.
FTN-19-00	FORMAT	Authorization for Decision Making	Document authorizing the making of decisions.
FTN-21-00	FORMAT	Emergency Directory	Updated directory of heads of institutions.
FTN-22-00	FORMAT	Operations Control Center equipment	Data to be determined in the implementation phase once the Business Continuity Subcommittee meets and equipment is determined
FTN-23-00	FORMAT	Strategies for Suppliers	Establishes how providers should be selected according to the options listed for each provider.
PST-08	PROCEDURE	Internal and External Communication	Establish, implement and maintain processes for internal and external communications with the business continuity.

The following are key elements that are considered in the BCP:

Personnel

Considering that the integrity of the people is the most important thing in the case of any natural disaster, mechanisms must be in place to protect and facilitate recovery work.

It is important to mention that, workers who have been affected in their personal life, should not participate in the duties related to the disaster recovery.

For the above, you must identify those people who have technical capabilities and experience in the care of natural disasters.

Among the recommended specialties are:

- Fuel quality control.
- Maintenance of supply vehicles.
- Electromechanical maintenance.
- Control systems.

- Supply of aviation fuel with refuellers.
- Unloading process of tanker trucks.

It is important to mention that currently ASA is the only provider of aviation fuel services in Mexico. This facilitates the incorporation of personnel in an environment with multiple companies involved. A cooperation agreement in case of emergency must be incorporated.

Communications

During the evaluation of a natural disaster, coordination of activities and communication with the different actors is key to the rapid recovery of operations.

In this regard, the following information is available to the emergency response team, which is formed to assess and address the different level of damages.

- Matrix of roles and responsibilities for the emergency care group.
- Documented disaster recovery procedure.
- List of workers in the affected areas, with contact telephone numbers of families.
- Directory with contact details of airport administration, airport authority, government rescue forces, medical services / Red Cross, police, among others, both local and federal.
- Directory with contact details for airlines, including General, Operations and Flight Directorates.
- Direct access to the General Directorate of the company, by the coordinator of the emergency response team, for quick decision-making.

Information systems

The loss of information during a natural disaster is a common effect that must be addressed.

For this, and taking into consideration the most relevant systems in the operation of the fuel farms and the service of into-plane, there is an alternate data center located in a zone of very low impact by earthquakes, floods or hurricanes.

In the event of a major disruption with ASA computers, which are located in Mexico City, an automatic switch is pressed in order to reestablish the availability of the systems in seconds.

It is important to mention that today, the 61 facilities where ASA operates have a direct communication to the computer site and, all data are stored in servers and replicated to the alternate data center.

Equipment

To restart operations as soon as possible, it is fundamental to have refuellers with different capacities that can supply airplanes and helicopters.

In the case of the Mexico City airport, although more than 90% of the fuel is supplied via a hydrant system, there is a fleet of refuellers of 20K and 40K liters capacity, which in normal operations serve remote positions, hangars and pre-load services.

In case of emergency, they serve as a response team inside and outside the airport. As they are designed to transit on highways. This is fundamental since in case of damage to the hydrant network, the refuellers are the only means of supply.

On the other hand, a mobile quality laboratory has the ability to recertify products according to JIG standards. Considering that the quality of the fuel is of the highest priority during emergencies, this laboratory can be

transferred to the affected area and can generate the necessary tests required to release the product for aeronautical use.

Finally, due to the problem of providing fuel to areas that are difficult to access in the mountains, a transportable unload skid is currently being developed that allows fuel to be transferred from a moving container to a refueller, to prevent the vehicles from having to move to the fuel farms.

Infrastructure and systems.

The following systems have been identified as key to mitigate / control damages that can be generated by an earthquake:

- Leak detection systems.
- SCADA systems with hydrant system pressure monitoring and automatic pump cutting.
- SCADA systems with automatic actuation of valves in tanks.
- SCADA system with level measurement per tank and supply measurement to the hydrant network.
- Leveling systems of tanks, at foundation level, in case of loss of verticality after the earthquake.

ANNEX 1 GENERAL CONSIDERATION FOR FUEL SERVICE PROVIDERS IN THE EVENT OF HURRICANE

Actions to be considered for aviation fuel service providers when hurricanes are imminent.

BEFORE

Infrastructure

- Carry out a risk and operational analysis of the supply vehicles.
- Carry out a maintenance program that includes the different areas or facilities of the Station, auxiliary services and supply vehicles.
- Have inspections and preventive maintenance to the processes of reception, storage and supply of fuel, auxiliary services, buildings and supply units.
- Have a program of calibration and verification of the equipment of measurement of volume, pressure, temperature.
- Have all the materials to cover or protect windows.

Personnel

- Have training program in emergency care (first aid, search and rescue, fire, evacuation, communication) for the staff of the Station.
- Have a program for testing emergency procedures.
- Carry out all the necessary Operative Analysis of the personnel for the attention during an emergency situation.
- Have emergency procedures.
- Coordinate with the Airport Security Committee.
- Determine the safe area within the Fuel Farm to temporarily house the personnel that will remain in the field during the emergency.
- Have a list and allocation of resources for the purchase of food for the staff that will remain in the field during and after the emergency.

Communication

- Participate in the Airport Security Committee.
- Have a directory of authorities, clients, suppliers and external supports updated.
- Have a communication procedure and assigned staff for this task.
- Have the satellite telephone service for the personnel of the Fuel Farm, which must perform periodic tests of communication with the corporate office and command areas.

DURING

Personnel assigned to the guard must remain in the safe area during the emergency.

AFTER

- Perform a check of all the personnel in the shift and a second check of personnel in their day of rest.
- Walk in the facilities, by responsible and technical-specialized or on-call staff, in conjunction with airport personnel, to verify offices, storage tanks, containment dams, emergency facilities, pipes, auxiliary services, etc.
- Apply order and cleaning procedures to restore access to operative areas.
- In case of damage to the infrastructure, activate the emergency plan of the Fuel Farm (see recovery plan procedure).

- Coordinate the support of rescue operations with the airport authority.
- Have a reporting protocol for the authorities through the airport authority commander and central offices.
- Document the event through the emergency assessment.

ANNEX 2. GENERAL CONSIDERATIONS FOR FUEL SERVICE PROVIDERS IN CASE OF EARTHQUAKE.

Actions to be considered during the earthquake presence for aviation fuel service providers.

BEFORE

Infrastructure

- Carry out a maintenance program that includes the different areas or facilities of the Station, auxiliary services and supply units.
- Perform inspections and preventive maintenance related to reception, storage and supply of fuel processes, auxiliary services, buildings and units of supply.
- Have signs of safety and hygiene, to:
    - Location of equipment
    - The existence of risks
    - Compulsory Action
    - Prohibition
- Define a meeting point.

  Have visual and sound alarms.

Personnel

- Have a training program in emergency care (first aid, search and rescue, fire, evacuation, communication) for the staff of the Fuel Farm.
- Have an emergency procedures.
- Have a Program for testing emergency procedures.
- Have a list of all the personnel, with shifts and contact information.

Communication

- Participate in the emergency drills of the Airport and with the corporate office.
- Have a directory of authorities, clients, suppliers and external support, updated.
- Have a communication procedure and assigned staff for this task.
- Have the satellite telephone service for the personnel of the Fuel Farm, which must perform periodic tests of communication with the central or command areas.
- Keep informed of the seismic alerts issued by the authorities.

DURING

- Once the seismic alert sounds is activated, you should start the evacuation in less than one minute.
- Concentrate personnel in the safe zones.
- Keep calm.

AFTER

- Perform a check of all the personnel in the shift and a second check of personnel in their day of rest.

- Tour at the station facilities, by responsible and technical-specialized or on-call staff, in conjunction with the airport personnel, to verify that there are no damages in: the offices, the storage tanks, the containment dams, the emergency evacuation exits, the pipelines, the pipes, the accessories, the auxiliary services, etc.
- In case of destruction to the infrastructure, activate the emergency recovery plan.
- Coordinate with the airport authority to support rescue operations.
- Have a reporting protocol for the authorities through the airport authority commander and central offices.
- Document the event through the emergency assessment.

EXTERNAL REFERENCES

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Document prepared by:

Aeropuertos y Servicios Auxiliares
Av 602 #161 Zona Federal AICM.
México, Ciudad de México, C.P. 15620

Mauricio Omar Arellano Villavicencio
Director, Fuel Services, Aeropuertos y Servicios Auxiliares

Elizabeth Luna Ramirez
Manager, Operations, Aeropuertos y Servicios Auxiliares
Mexico City, Mexico, Abril, 2017.

DAMAGE AND RECONSTRUCTION OF SENDAI AIRPORT BY THE GREAT EAST JAPAN EARTHQUAKE DISASTER

On March 11, 2011 at 14:46:18 (Japan time), 70 km off the east of Sendai City in Miyagi region, at sea level of the Pacific Ocean, in the Tohoku district Pacific coast, an earthquake occurred.

The magnitude of the earthquake was of a magnitude of 9.0 on the Richter scale. One of the largest earthquakes in the history of Japan. The epicenter was vast, and the broad range of about 500 km north and south from Iwate prefecture, off the coast of Ibaraki area which is about 200 km from east to west. It was considered as the epicenter area. The maximum seismic intensity was 7 on the Richter scale. It was observed in the Miyagi region with a seismic intensity of 6 within 36 municipalities in various cities of the east coast of Japan.

The earthquake that occurred at around 14:46 on March 11, 2011, was released by Japanese government as East Japan Greatest Earthquake Disaster.

Due to this earthquake, a huge Tsunami occurred with a wave height of 10 m or more and a maximum uphill height of 40.1 m depending on the location, causing catastrophic damages to the east coast region. There were 15,894 deaths, 6,152 injuries and 2,561 missing persons reported to the police office.

Figure 11-Photo 1. Tsunami near Sendai Airport (Source, Kawakita Sinposya)

Sendai Airport (SDJ) is main airport in this area and the runway was closed immediately after the earthquake occurred. About 1,400 people including passengers, surrounding residents and employees were evacuated in the terminal building.

At 15:56, on March 11, 2011, one hour after earthquake occurred, the airport and the related facilities were flooded by the tsunami. The airport terminal building was also greatly damaged. The airport operations were completely stopped.

The terminal building was flooded to a height of 3.02 m and a large amount of automobiles and debris flowed into the first floor of terminal building. Although there were no airliners aircraft in the parking, a total of 67 general aviation aircraft and helicopters were damaged by the tsunami.

About 1,400 people who were waiting for help were isolated, but almost all were rescued on the March 13. It was three days after earthquake and tsunami occurred.

As of April 13, the domestic flights operation resumed for the first time in a month. On July 25 domestic flights regular service for the first time in about four and a half months resumed its operation. On September 25, the airport building was also fully restored, and international scheduled flight restarted.

It goes without saying that there was a great deal of support from the US military about restoration of Sendai Airport and other many areas. This close cooperation became known as the “Friend Strategy”, and the Japanese will never forget their support.

Figure 12-Map-Japan Country

Sendai Airport Fuel Facility

Sendai Airport (SDJ) is the main airport of north east of Japan and there are 2 runways of 1,200 m and 3,000m. Domestic and various international airlines operate in this airport, from Asian cities and from Guam. Aviation University is located at this airport and many general aviation aircraft of training school runs there too.

Pacific Co., Ltd. (PAC) owns and operates the fuel facility and into-plane services in this airport. There are four (4) Japanese suppliers supplying fuel from domestic refineries through the Sendai harbor intermediate storage.

A 1,000 KL capacity of 2 fuel storage tanks in the facility and into-plane operates by refueller. There are three (3) fuel receiving bays and three (3) fuel loading bays in the facility, including a refueller maintenance garage.

PAC and the fuel suppliers' serve in this airport with a total of 15 refuellers and 100,000 liter of fuel supply to the aircraft per day.

PAC communicated and gave a detailed explanation of the situation at the time of the disaster with a description of the reconstruction labor.

Situation at the Earthquake

The fuel facility collapsed due to earthquake and immediately evacuation orders were announced by the fire authorities in preparation for the tsunami. Since the quick arrival of the tsunami and its destructive power, it was crucial as an administrator to give priority to human life. In order to prevent a secondary disaster, it was necessary to take measures to prevent outflow of fuel. Because the magnitude of the earthquake was huge, it was predicted that the tsunami would reach the airport rapidly. Due to the lack of time it took, a minimal emergency measures were applied and, staff could not retrieve the documents. PAC operators immediately closed the main receiving and delivery valve before the tsunami immersion and evacuated to the Sendai Airport building.

At 15:56 March 11, 2011, it was one hour after the earthquake occurred that a 20 m height tsunami reached from the Pacific coast up to the east area of Sendai Airport. This situation looked like a huge bulldozer crushing the buildings, houses and everything on its path.

Many peoples, passengers, airport staffs, peoples living near the airport were evacuated in Sendai Airport building. Communication was completely blocked for next three (3) days, until the water withdrew.

The area around Sendai Airport is flat with a few high buildings. The higher floors of the building at Sendai Airport were the only place to evacuate the tsunami safely. Sadly, not everyone made it to the building.

Major facilities that were damaged completely were the storage facility, the pumping station, the fuel loading and unloading, and all the pipes. However, storage tanks had no serious damages and did not float.

The debris were being washed away by the tsunami and circulated around the storage tank, as it was surrounded and protected by the pumping station and other buildings. This prevented the flood from getting into direct contact with the storage tank. Also, fortunately, the tank did not float because of the large amount of fuel in the tank remaining inside, which was filled at the time with fuel up to 80% of its capacity.

Refuellers were at the apron and in the storage facility. A total of 15 refuellers were damaged and drifted with the flow of the seawater.

Many documents, operation manuals, fuel quality control records, training records and certifications were widely spread due to the tsunami and had significantly signs of water damages.

Evacuation report was canceled three days after the earthquake and tsunami occurred. Efforts started for restoration. Meanwhile, the home and the family of PAC employees suffered greatly, and restoration work was emotionally and physically difficult. Some employees lost their families.

Accumulated debris in the fuel facility, due to the tsunami made restoration by human work impossible. Heavy machinery was necessary to remove the heavy materials. Due to the need to restore the lifeline following the earthquake and tsunami, the necessity to quickly restore Sendai Airport has made it possible with the help of

the US military. They were a major contributor of the restoration of the fuel facilities. The US military introduced heavy machinery and quickly removed debris in the fuel facility. However, what was left of the office building was clogged with tsunami drifting objects, and these were forced to be removed manually.

Figure 13-Photo 2. Sendai Airport Fuel Facility after Tsunami

Fuel Storage Tank

The tank is installed on a 0.65 meter concrete foundation. It was submerged to a height of 2.4 m from the ground level by the tsunami.

There were a loading rack and other building on the upstream side against the flow of the tsunami. The buildings were able to block the flow of the tsunami, drift materials and debris away. It permitted to prevent it to collide directly with the tank. As a result, the tank was not affected. Also, no major damage was found on other equipment.

However, electric equipment such as fuel level gauging and thermometer were destroyed by seawater.

At the time of the earthquake, about 80% of the total capacity of the tank was stored. It was about 800 kl of fuel. The buildings close by and the weight of the tanks filled with fuel prevented the tsunami to seriously damage them. In Japan, earthquakes occurs frequently, and for this reason there are strictly prescribed safety standards for buildings against earthquakes according to the Building Standard Law. There were no cracks or deformation of the tank foundation. However, a part of the ground inside the oil proof barrier was vanished by the influence of the strong tsunami flow.

The fuel remaining in the storage tank was safe and tested again at the refinery laboratory in accordance with joint checklist and, we were able to supply the aircraft.

The fuel was withdrawn from the tank and a construction inspection of the tank bottom plate was carried out. Weld repairs were done where we found issues. The degree of damages of the two tanks were minor and repairs were completed in a short period of time.

Figure 14-Storage Tank

Fuel Receiving and Loading Bay

There were no serious damages to the fuel receiving bay, but the destruction of the fuel loading bay was enormous. The Tsunami hit the fuel receiving site, all the flowmeters and piping. They were entirely destroyed.

Of course, all hoses and pipes with small diameter were destroyed, and in addition, since seawater flowed from the slop tank and the piped section where it was destroyed, later damage caused by sea water was found in various places.

Figure 15-Fuel Loading Facility

Filter Facility

There are two micro filters for fuel receiving and two filter water separators for fuel delivery in the facility.

In the filter facility, many of the debris that were being washed away by the tsunami had accumulated but luckily it slightly damaged the pipes and the filter vessel. Due to a building protecting the filter facility, it deviated the direction of the tsunami although some seawater filtrated the drain tank. The foundation was also found damaged.

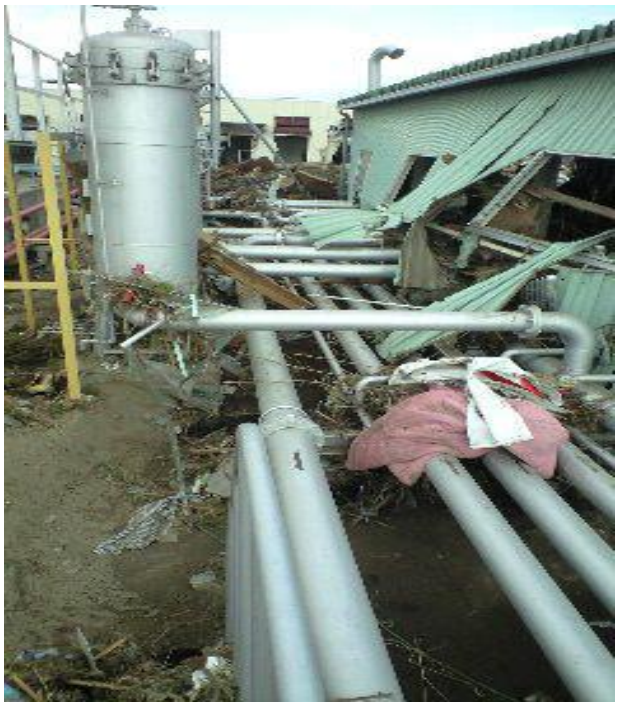


Figure 16-Filter Area and Piping

Piping

Regarding the fuel piping, although there was a part which was lost due to the influence of the tsunami, the remaining piping were also in a state where it could not be reused. They were immersed in seawater for a long period of time. Throughout the investigation, we verified any existence of microbiological growth in the pipes due to the remaining water found inside. All pipes were removed and replaced or refurbished at the manufacturer. Especially, outer surface of pipes were corroded due to sea water.

In addition, since the debris and sediment caused by the tsunami flowed into the pit where the pipes were installed, it was necessary to start with the work of removing manually all the debris and sand.

Pumping and Electrical Station

Damages to the fuel transfer pump station and the electric facilities were enormous, and most of the equipment destroyed by the tsunami. Not only had the fuel storage facility fallen but also to the whole area around Sendai Airport, the electrical transmission tower collapsed due to the earthquake. To that end, all of the power transmission had been stopped. Also, auxiliary power equipment and battery facility were lost.

Since the debris caused by the tsunami flowed into the pits for electrical wiring installed in the fuel storage facility, it was urgent to eliminate manually all the debris.

Figure 17-Fuel Pump Station

Firefighting Facility

The tsunami submerged the entire firefighting facilities. It destroyed all fire extinguisher pumps, part of foam fire extinguishing piping, and other pipes.

Office Buildings

The inside of the building was completely destroyed and lot of drifting matter such as car, rubble and soil due to the tsunami were discovered inside the office building. Many documents drifted with the current making the search extremely difficult. Most of the documents that were discovered were immersed in water and were damaged severely making it difficult to descript. Therefore, the documents necessary for restarting operations were subsequently ordered from the oil companies.

Figure 18-Inside of Office Building

Refuellers

In SDJ, 4 suppliers supply fuel to the storage and a total of 15 refuellers were assigned at that time. The capacity of refueller is 20 KL and 12 KL, and 2 refuellers in the airport ramp and 13 refuellers in the storage facility. The refuellers in the storage facility were completely destroyed by the tsunami, and 2 refuellers in the airport ramp were damaged by sea water by tsunami.

After the earthquake, the powerful tsunami reached Sendai airport rapidly and made it impossible to evacuate the refueller into a safety zone.

All the refuellers were considered scrapped because they were soaked in the seawater, due to the tsunami. The fuel left in the tank of the refueller passed a fuel quality test. The fuel which could be confirmed with no contamination could be used again. The fuel tested at the refinery laboratory was in accordance with the joint checklist.

Figure 19-Motor Pool

Figure 20-Refuellers

Reconstruction Summary for Sendai Airport Fuel Facility

An overview of the recovery is described below.

Storage Tank No.11: Bottom plate ultrasonic inspection was completed on August 23 and bottom plate repair completed on September 28. It included tank cleaning.

Storage Tank No.12: Bottom plate ultrasonic inspection was completed on November 8. It included tank cleaning.

Pipes: Accomplished inside condition check all piles and completed on June 7 and work completed on July 11 including some part of delivery pipe replaced and blasting.

Pumps: Receiving pump motor replaced on April 26 and delivered the pump motor overhauled at the manufacturer on May 31. All fuel pumps overhauled at the manufacturer on May 27.

Instruments: Tank level gauge replaced on August 7 and delivery flow meter replaced on August 24.

Firefighting System: Temporary pipes were installed on May 2 and Electrical Panel fixed on August 1. Emergency Power was replaced on September 4.

Electrical Power: Electrical power was supplied again on July 20 after all wires and panels were replaced.

Building: Fuel loading rack repairs were completed on July 24. Fuel pump and firefighting pump building repairs were finished on July 23. Office building repairs achieved on September 4.

Due to the massive damage caused by the tsunami in addition to the damage caused by the earthquake, the restoration work was extremely challenging.

After the water was pulled away by the tsunami, PAC gathered the employees and started restoration. PAC started from searching the required documents such as regulations, qualifications, and fuel test reports and so on. Most of the documents were completely soaked.

Staff were manually removing small debris. Later, heavy machinery arrived, with the support of the US military, and we were able to remove large debris.

Some of the domestic flights started one month after the earthquake after removing the drifting objects filled with earth and sand caused by the tsunami in the airport.

All refuellers could not be used due to the damage caused by the tsunami, and alternative vehicles were collected from other airports by suppliers.

At this point, since the fuel supply to Sendai Airport was not restored, the fuel remaining in the storage tank and refueling vehicle tank were used after the laboratory confirmed its quality via a recertification test.

Fortunately, there was a lot of non-contaminated fuel remaining, until the fuel refueling system was restored, The emergency aircrafts were used to search for victims, provide transportation for food, medical assistance, living supplies and evacuation materials of evacuees. Since the fuel facilities were not restored, during this time, with the permission of the fire department authorities, the fuel was transferred between the refueller via the filters.

After the restoration of the electric facility, fuel supply started from the facility tank. A constructive inspection of the tank bottom plate were carried out at the time when all the fuel of one tank was used out of the two fuel facility tanks, and since issues were found in part of the tanks, the welding repairs were done. Sendai Airport fuel facility was completely restored in November, 2011, eight months after the earthquake occurred.

Japan is an earthquake-prone country, and daily preparations for earthquakes are established. In addition, regular training is also conducted. Strict standards are imposed on all buildings including fuel storage tanks under the Building Standards Law of Japan. It is nearly impossible to predict a huge earthquake and tsunami like the Great East Japan Earthquake. There is also nothing to do with human's power against such a devastating earthquake. No one could have expected the attack of a huge 20 meters tsunami.

After experiencing this disaster, PAC re-examined facility equipment and document management. Because the tsunami carried many things such as automobiles and timber and debris from the collapse of houses. It is important to prevent them from directly colliding with the fuel tanks and other facilities. It can be said that the protective fence is effective against the direction of the flow of the water in order to prevent a direct influence of the tsunami. It is also necessary to evacuate the refueller to a safety zone. Airports are built on a flat surface, which makes it limited to find evacuation areas. Another major issue are that GSE vehicles are found besides refueling vehicles, blocking its swift access. Realising that no company can deal with a natural disaster alone.

Towards the resume of aircraft refueling operations, it was an obstacle that the documents were flowed out by the tsunami. For these reasons, important documents such as regulations and qualification certificates are kept now in electronic format, and those that are carried out in an emergency case kit which are exclusively used when there is an official emergency. Such effective countermeasures are also provided to the airport refueling facilities nationwide.

Another problem and concern is the reuse of fuel remaining in tanks and refueling vehicles. In the state where the supply route are discontinued due to the earthquakes, it is crucial to start with the reconstruction and restart of the airport operations. For that purpose, refueling at the airport is indispensable, and in the situation where the supply route on the ground is unusable, it is necessary to use the fuel left in the facility tank and the refueling vehicle. Upon fuelling resumption, we sent the fuel sample to the supplier's laboratory, tested it and confirmed its quality, but it was not easy.

Due to the damage and experience of the Sendai Airport refueling facility with this natural disaster, suppliers and their associations as PAJ, Petroleum Association of Japan developed a BCP (Business Continuity Plan) in order to quickly resume business activities, continued.

Figure 21-Fuel Sampling from Storage Tank by US Military

Figure 22- Restoration Work by Japanese Defence

Figure 23-Restoration Work by US Military

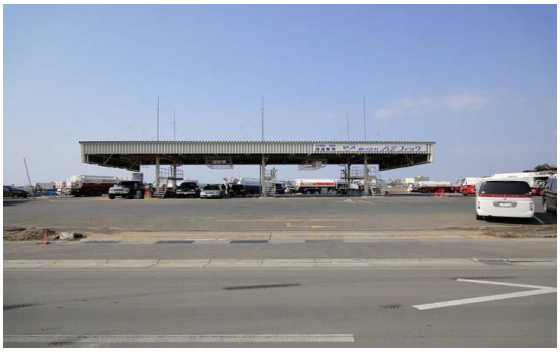


Figure 24-Fuel Loading Station after Restoration Work

Figure 25- Fuel Storage Tank after Restoration Work

Figure 27-First Flight after Airport Recovered

Reference:

Sendai Airport is located at about 14 km south-southeast of Sendai Railway Station in Sendai City, which is close to the coast of Middle-south part of Miyagi prefecture. It is connected by Sendai Airport Access Line (Airport Connection Railway).

There are two runways: runway “A” is 1,200 m and runway “B” 3,000m. They are newly established, and cross each other in a "y" shape. Basically, the runway “A” is used by a general aviation aircraft and the runway “B” is used by large aircrafts.

The current terminal building started operation of the whole building in July 1997. There are a total of 52 stands spots in the airport, 3 international, 10 domestic and all the rest are for general aviation aircrafts.

Prepared by:

Yukio Mashimoto
Manager
Airport Center, All Nippon Airways Co., Ltd.

Shin Onodera
General Manger
Sendai Refueling Section, Aircraft Refueling Department
Pacific Co., Ltd.

PART III. EXPERIENCE FOR FLOOD; EXPERIENCE FLOOD IN BANGKOK AND HISTORY OF HURRICANES IN MEXICO.

BAFS SUVARNABHUMI (BKK) – DEPOT & AIRPORT FLOOD CRISIS PROTECTION

Suvarnabhumi Airport (BKK Airport)

Thailand's main aviation gateway was opened for commercial operations on September 28th, 2006. Suvarnabhumi Airport has a polder system. The polder system is designed to protect the entire airport site from external flooding by the construction of a perimeter dike of 23.5 km in length with external and internal drainage canal, 5 storage ponds and 2 pump stations.

Into-plane Office

The into-plane services consists of the operation office, the maintenance shop, and the testing/calibration facilities. The into-plane office is located within Suvarnabhumi airport flood protection area.

BAFS Main Depot

BKK-Depot incorporates 100,800 m^2 of area on the eastern part of Suvarnabhumi airport. It is crossed in the middle by the Nong-nguhao canal. At that time the main tank farm includes 4 x main storage tanks with a combined capacity of 60 million litres. Product was supplied by 2 pipelines, where each came from a separate source.

BAFS Don Mueang (DMK) – Depot & Airport Flood Crisis Rehabilitation

In 2011, Thailand witnessed its worst flooding in half a century, leaving severe impairments to the country's economy, industrial sector, and society. Factors that contributed to flood crisis range from natural to manmade. Consequently, floodwaters inundated 90 billion square kilometres of land, more than 2/3 of the country. Ranking the natural disaster as the world's fourth costliest disaster since 2011.

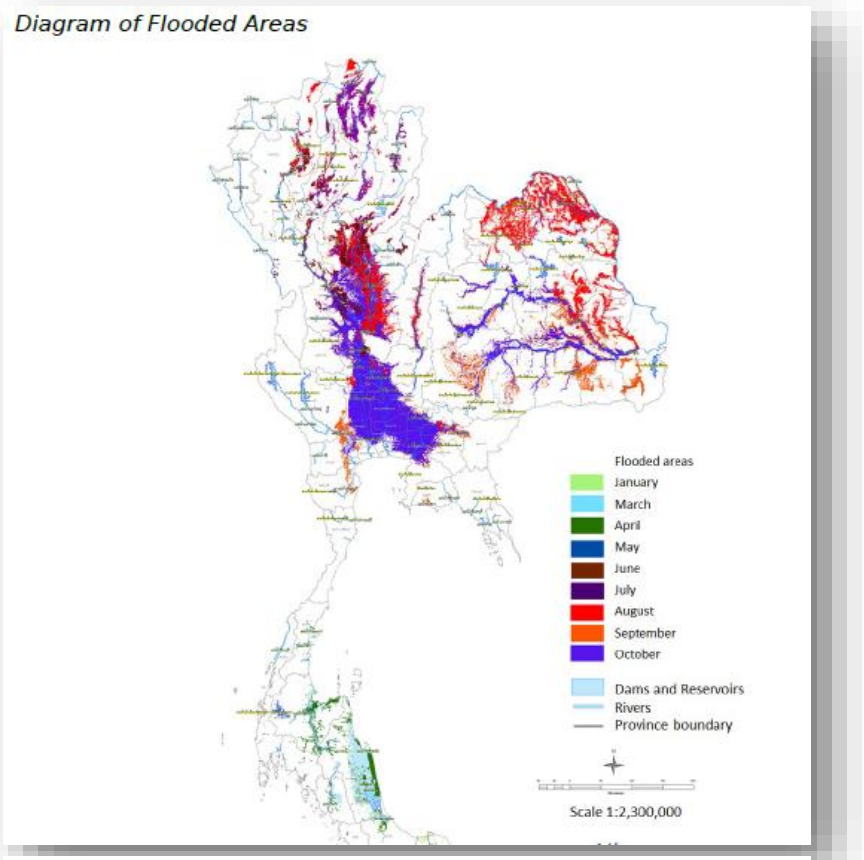


Figure 26-(Source: Geo-Informatics and Space Technology Development Agency. 2011 Thailand Flood Execute Summary)

On October 25, 2011 (pre-incident response), BAFS prepared a flood protection plan by making a 1.3 meters clay dike at the northern area, constructing sandbag barriers, reinforcing the fence and providing additional water pump.

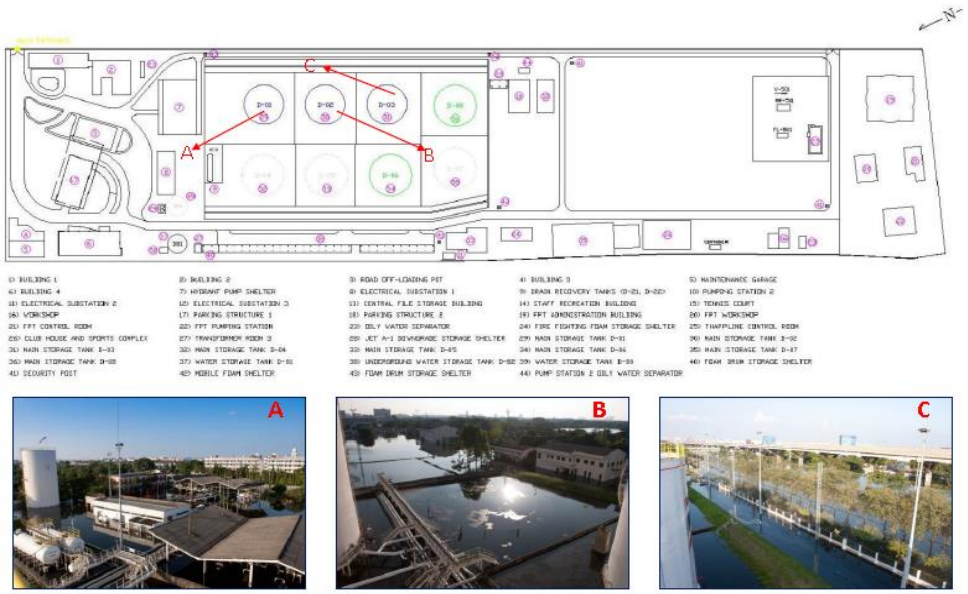
At the end of October 2011 the flood arrived Vibhavadi Rangsit road and Premprachakorn canal. Thus Don Mueang area became a flood crisis area.

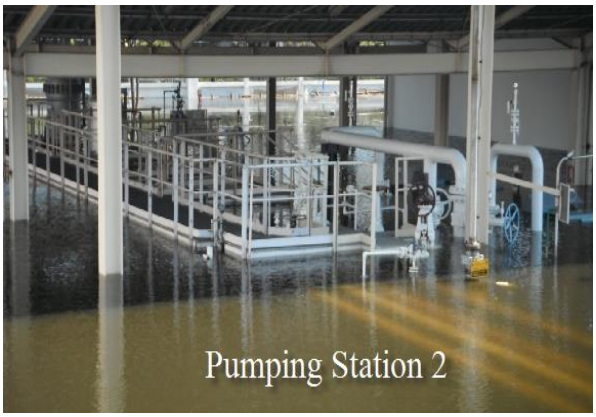
DETAILS OF DAMAGE SITUATION

Depot

In the night of 31 October 2011, the flood water from Premprachakorn canal breached the western perimeter fence, causing a 30-meter section of the fence to collapse, and rapidly covering the depot under 1.5 meter of flood water.

BAFS Donmueang Depot Layout

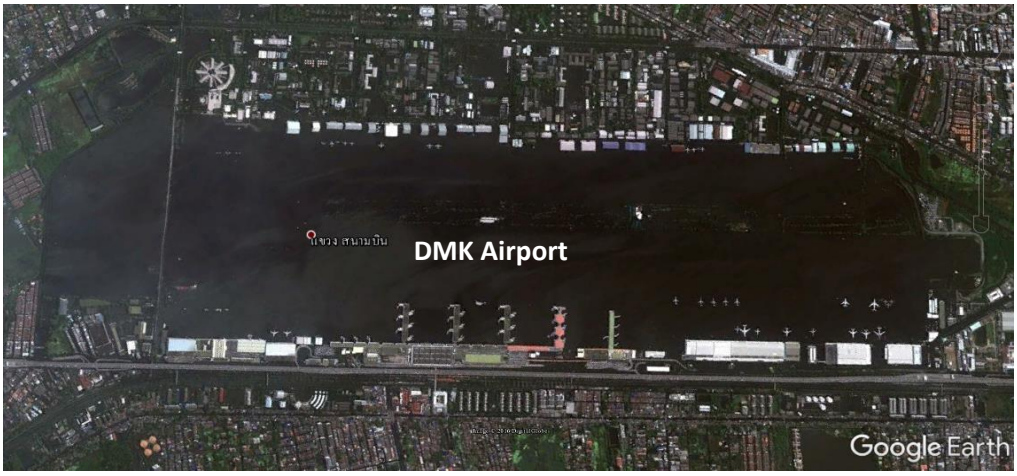




Airside

The Into-plane substation is located on the airport apron. It comprises of an office building for into-plane staff, a parking area, a maintenance shop, an underground tank with transfer pump, and a fuel loading/testing facilities for refuellers and dispensers. They were also affected by the flood.

The city's secondary airport (Don Mueang) at that time was partially operated with only aircraft maintenance. When the flood arrived, it was forced to close in October 25, 2011 after a floodwater crept into the main terminal building, and also over the facility's runways. The airport was re-opened to commercial flights on March 2012, after the eastern runway had been repaired.



Recovery overview and countermeasure

On November 1, 2011, the company immediately established a Don Mueang Rehabilitation Committee (DRC) to coordinate and expedite all recovery, repair, and rebuilding efforts, with the aim of resuming normal operations as soon as possible.

The DRC's rehabilitation plan was divided into 3 phases as follows:

- **Phase I** for short term activities or immediate action (within 5 days)
- **Phase II** for intermediate term activities (within 2 – 5 months)
- **Phase III** for long term activities (within 10 - 12 months)

Phase I

- To lift refueller truck cabs to prevent water entering the engine (all refuellers had been firstly moved to the higher area of the airport).
- To save and recover basic utilities, e.g. power, water, food, communication and sanitation, including a providence of a transportation means to and from the site.
- To control water level within main storage tank area to ensure that it is below the tank concrete foundation level (otherwise the tank could float).
- To check for hydrant system condition after flooding including fuel leak, hydrant pressure.
- To control fuel film migration within the area and protect it from fuel leaks under the tank.

Phase II

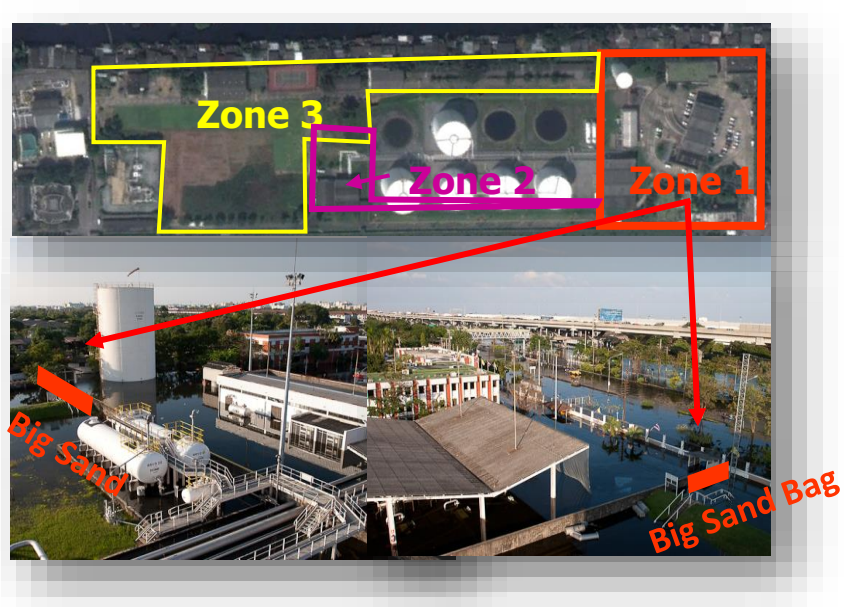
- To control hydrant pressure at 10 bar preventing water from entering the system.

- To classify the zone for critical or non-critical areas such as hydrant pump area, tank area or office area and control critical area by putting big sand bags and pumping out zone by zone.
    - **Zone 1:** Electrical equipment, Hydrant pump, Office building
    - **Zone 2:** Transfer pump
    - **Zone 3:** Multipurpose area
- To recover and repair firefighting system.
- To recover and repair product receipt, delivery and storage systems to enable fuel supply to the airport.
- To transfer one hydrant pump from Suvarnabhumi airport into-plane facility to the Don Mueang airport depot hydrant pump shelter for temporary hydrant pump.
- To transfer one transfer pump from Suvarnabhumi airport into-plane facility to the Don Mueang airport substation for temporary refueller loading pump.
- To inspect, monitor and maintain fuel quality in tanks and piping system, such as hydrant low point checking and flushing, valve chamber inspection, circulate hydrant pipeline and recertification test.

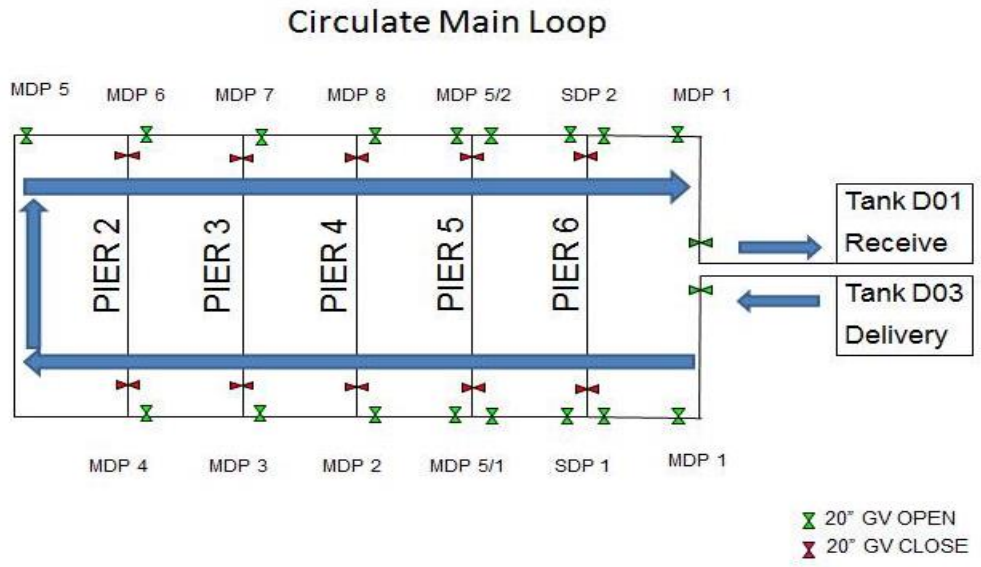
The results of hydrant fuel Quality Control Check as follows;

- Hydrant Low Point Flushing (Visual Check) : C&B
- Random check for fuel conductivity : 127 pS/m
- Hydrant Low Point Sampling for Recertification Test : On Spec. Limit
- Circulate hydrant pipeline and Recertification Test : On Spec. Limit

To provide temporary electrical power via mobile diesel generator.




明辉机电


Circulate Main Loop
MDP 5
MDP 6
MDP 7
MDP 8
MDP 5/2
SDP 2
MDP 1
PIER 2
PIER 3
PIER 4
PIER 5
PIER 6
Tank D01
Receive
Tank D03
Delivery
MDP 4
MDP 3
MDP 2
MDP 5/1
SDP 1
MDP 1
20" GV OPEN
20" GV CLOSE


27/12/2011


27/12/2011

Phase III

- To inform the insurance companies and survey for damaged equipment and building. All damage were claimed from the insurance companies.
- To reinstate permanent facilities, systems and equipment.
- To reconstruct of permanent flood protection facilities such as fence with pile & reinforce concrete.
- To relocate the control room from ground level to third level.
- To relocate the IT equipment to second level.
- To provide mobile flood protection door (stop log type).
- To increase the height of concrete wall around pump station, diesel generator, firefighting pump, electrical equipment room, etc.

- DMK has started refuelling services again by using refueller trucks on December 16, 2011 for charter flights.
- Airports of Thailand (AOT) built a new DMK Airport fence with pile & reinforce concrete.


Conclusion and Propose to Industry

- BAFS group (BAFS/Tarco) have reviewed and improved the emergency manual, including flood crisis procedure, comprising of preparation, response and recovery plan.
- Emergency plans are regularly practiced at least annually in rotation plan.
- Business Continuity Plan (BCP) is in place to prevent business interruption.
- The determination of future design and equipment shall be emphasized of flood such as installation level, location and mobile application.
- Recurrent training of all relavent staff for how to use mobile flood protection door is practised reguraly.

Flood protection during crisis in 2011

Suvarnabhumi Airport (BKK Airport)

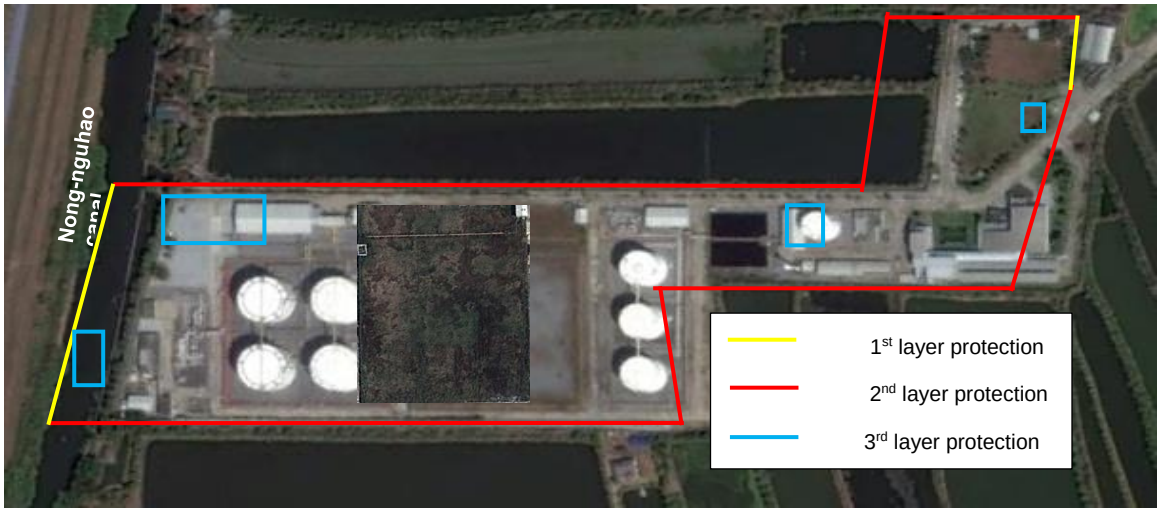
The flooding protection programme of BKK airport was divided into 3 levels;

BAFS Into-plane substation

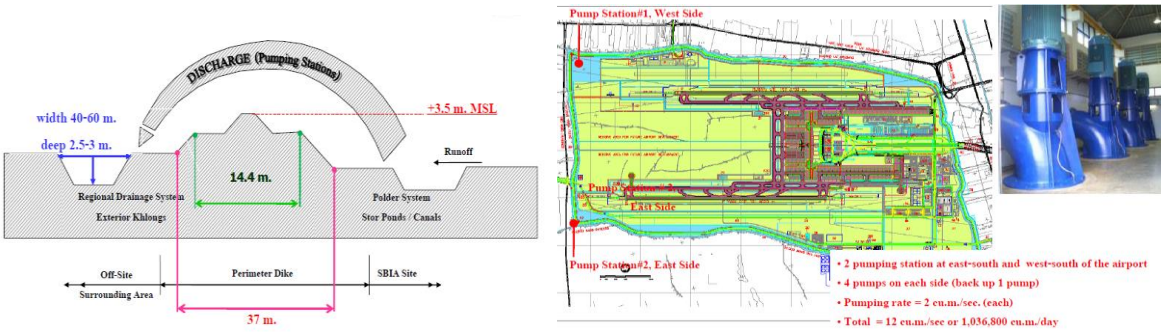
Since BAFS into-plane substation is situated within the airport boundary, it followed Suvarnabhumi Airport flood protection programme.

BAFS Main Depot

To divide a flood protection system into 3 layers.



Level 1: Improvement for existing flooding protection system e.g. 50 cm added dike, access road protection, reservoir and pumping station.



Level 2: Monitoring plan for all information including water level inside and outside airport area, dike monitoring for safety and security, analyse/evaluate data and report to executive, One Stop Service Centre (SOS) and public relation.

Level 3: Contingency plan

- To provide repairing material such as sand bags, steel pile, wooden pile, gabion, vehicles and man power.
- To inform all relevant parties for critical water level around the airport. Warning level for preparation to evacuate was +2.0 MSL (water increase slowly) and +1.5 MSL (water increase quickly).

The first layer were;

- To protect chain link fence by putting 5 rows of sand bags with plastic sheet, with an overall height of +2.50 MSL.

- To make compressed crushed rock ridge at the entrance gate.



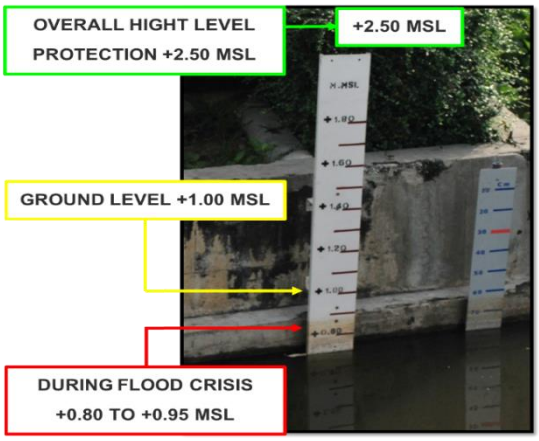

The second layer was;

- To reinforce the fence by putting a support sand bag, steel pipe or wooden pipe and plastic sheet added around depot boundary.


The third layer was;

- To protect critical equipment e.g. hydrant pump shelter, electrical equipment & electrical substation, storm water pump, firefighting equipment by adding brick wall and sand bag wall.

- To provide additional water pump.
- To improve flood drainage system to Nong-Nguhao canal.
- To provide spare sand bag in case of flood water leak into system.
- To provide mobile generator.
- To monitor for increasing of water level in Nong-Nguhao canal.
- To monitor information form authorities and Airports of Thailand (AOT).



EXISTING STORMWATER PUMP:

DIESEL ENGINE WATER PUMP: 1 X 3,600 m^3/hr

ELECTRICAL WATER PUMP: 2 X 2,160 m^3/hr

2 X 120 m^3/hr

MOBILE WATER PUMP:

DIESEL ENGINE MOBILE PUMP: 3 X 120 m^3/hr

MOBILE PUMP: 1 X 100 m^3/hr

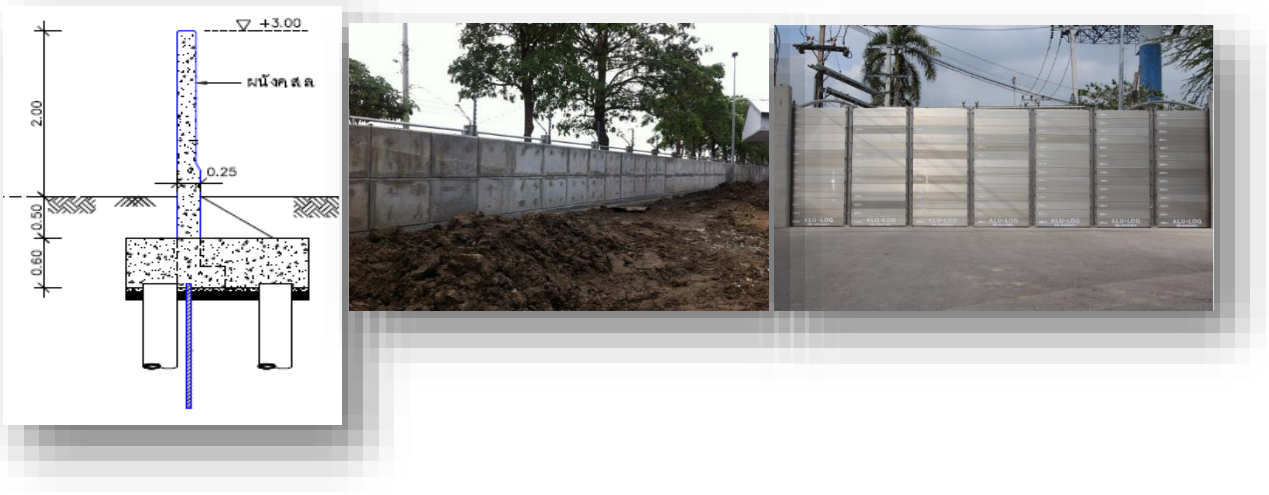
MOBILE PUMP (By Government): 1 X 550 m^3/hr

TOTAL Flow Rate: 8,930 m^3/hr

Permanent flood protection improvement for BAFS-BKK depot after flood crisis

However, BAFS-BKK depot was an unaffected area in 2011 but we had experience and implemented the lessons learned from DMK. The company has decided to make a permanent flood protection as follows:

- To construct concrete fence of a height of +3.00 MSL and an underground concrete sheet pile depth -2.00 MSL to protected flood water leaks.
- To provide mobile flood protection door (stop log type).
- To install two new drain gates for storm water drainage.



Conclusion and Proposal to Industry

- Airports of Thailand (AOT) has revised and improved their emergency manual.
- BAFS group (BAFS/Tarco) have reviewed and improved their emergency manual including flood crisis procedure, comprising of preparation, response and recovery plan.
- Emergency plans are regularly exercised at least annually in rotation plan.
- Business Continuity Plan (BCP) is in place to prevent business interruption.
- The determination of future design and equipment shall be emphasized of flood such as installation level, location and mobile application.
- Recurrent training of all relevant staff for how to use mobile flood protection door is practised regularly.

PART IV. PIPELINE AND HYDRANT SYSTEM RECOVERY PROGRAM AFTER EARTHQUAKE;

INTRODUCTION

Narita International Airport (NRT), previously named New Tokyo International Airport, is Japan's leading airport located at 45 km east of Tokyo. It has two runways, one of 4,000 meters and another of 2,500 meters.

Two fuel storage facilities are installed at the airport, and all aircraft refueling is done through the hydrant system.

Japanese fuel companies supply fuel through the Chiba Port located south from Narita International Airport. The fuel refineries are located in various areas of Japan, and is transported by barge. Fuel is unloaded from tanker to Chiba Port Storage Facility, and after a quality control test, fuel is sent to the Narita International Airport fuel storage facility, through a 47 km pipeline.

As it is well known, Japan is an earthquake-prone country, and the area where Narita International Airport is located is also designated as an area where earthquakes may often occur. The most severe earthquake at Narita International Airport was the Chiba Prefecture Toho - Oki Earthquake that occurred on December 17th, 1987, and the earthquake strength at that time was 448 GAL and magnitude of 6.0.

The maintenance of the function of Narita International Airport is very important for Japan. Measures against earthquakes have been established, and the refuel supply system is one of them. In the following paragraphs, I introduce the seismic detector of Narita International Airport, the recovery procedures of the pipeline, and also the hydrant system after the earthquake occurred.

Figure 27-Narita International Airport

Fuel Supply and Storage Facility Outline

Narita International Airport is located inland of Chiba area and fuels are supplied through a 47 km dedicates JET A-1 aviation fuel pipeline from Chiba Port.

The pipelines have a diameter of 14 inch and fuel runs through two (2) pipes at a flow rate of 700 KL/Hour per line with a 2.89 MPa pressure and 7.2 Feet/Sec flow rate. Pipeline starts at Chiba Port storage facility and run through the tunnel where it runs under the river and continue underground up to Narita International Airport along the freeway. In the middle of the way at Yotsukaido, there is a pumping station of the pipeline.

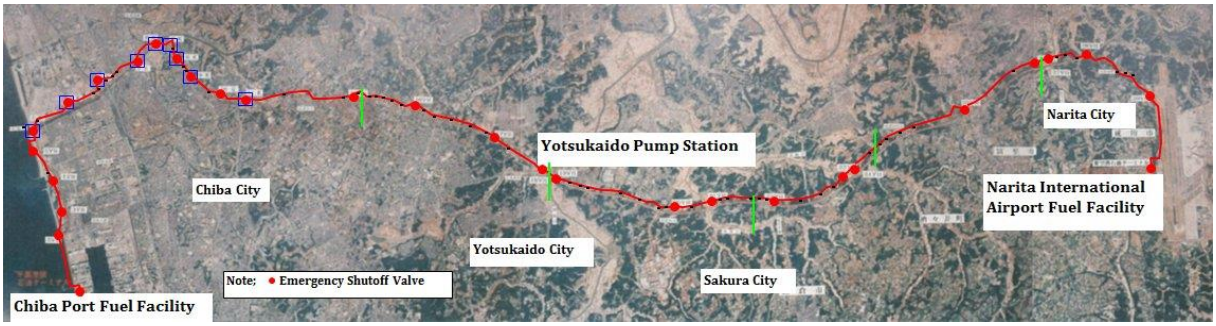


Figure 28-Pipeline Route Map

At Chiba Port fuel unloading station, there are 4 jetties and a maximum of 8,000 tons tanker that can bridge the jetty. There are 13 storage tanks with a total storage volume of 95,000 KL.

A fuel test laboratory is located in the storage facility and a re-certification test is carried out after the fuel is unloaded from tanker.

Figure 29-Chiba Port Fuel Storage Facility

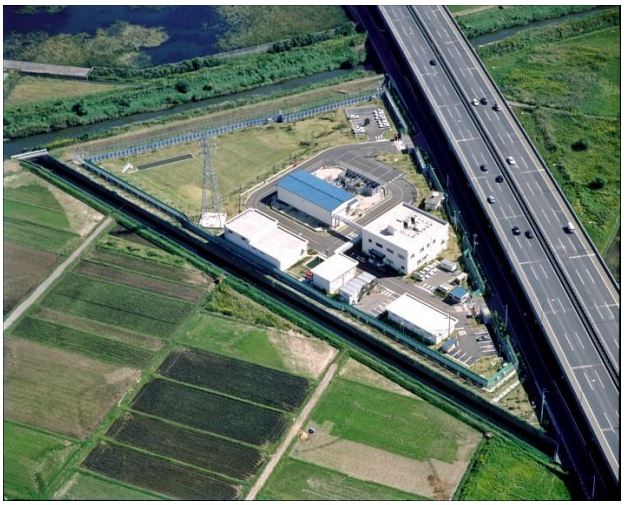


Figure 30-Yotsukaido Pump Station

Narita International Airport has 33 storage tanks with a total storage volume of 192,000 KL, and at least 7 days stocks is maintained. Fuel is received into the No. 1 storage facility from pipeline through incoming micronic filters and filter water separators. Some of the storage tanks are fitted with a floating roof and fuel settled to an appropriate settling time. After settling and a fuel control check, the fuel is delivered to the hydrant system through the into-hydrant filter water separators.

Figure 31-Narita International Airport Fuel Storage Facility

Various fuel leak detection sensors are installed at appropriate intervals along the length of the pipeline. An emergency shutoff valve is located at Narita International Airport No. 1 storage facility, Chiba Port storage facility, and at 28 other locations between the pipelines.

Concerning the earthquake communications, a seismograph is installed at three (3) locations at Chiba Port Storage Facility, Yotsukaido Pump Station and Narita International Airport Storage Facility. It is to detect seismic disturbance at the instant it occurs. The pipeline is monitored in the control room for 24 hours, the pipeline

automatically stops. The device works in accordance with the strength of the earthquake, and the fuel transfer is immediately and automatically stopped.

Narita International Airport Hydrant System Outline

There are 2 storage facilities located in the airport. There are 25 storage tanks in the No.1 storage and 8 storage tanks in the No.2 storage facility. Fuel is received into No. 1 storage facility from pipelines after a control check. Fuel is transferred to No.2 storage facility, during the night to an adjusted volume to fuel supply of No.2 terminal. Usually, fuel supplies part of No.1 passenger terminal and cargo terminal hydrant system from No.1 storage facility. No.1 and No.2 passenger terminal and maintenance area hydrant system are supplied from No.2 storage facility.

The total hydrant pit number is 431. The maintenance and major inspections are accomplished during the night time. Narita International Airport closes from 11 o'clock pm through 6 o'clock am.

In the event of an earthquake, the supply of fuel to the hydrant system is immediately and manually stopped, depending on the strength of the earthquake.

Earthquake Response Measures Procedure

Narita International Corporation (NAA) established Earthquake Response Measures Procedure that defines basic procedures for countermeasures at the time the earthquake occurred. However, if a fuel leak occurs in the pipeline and it's the associated facility (including hydrant system), it is enacted in the Narita International Airport Fuel Pipeline Security Regulations, and measures are taken according to this rule.

The response method is decided following one of the 4 cases below according to the acceleration of the earthquake.

Figure 32-Seismograph

Figure 33-Visual Inspection for Pipeline in the Tunnel Area

Case A.

Seismic acceleration 0.10 m/s2 (10 GAL) or more and less than 0.25 m/s2 (25 GAL).

In the case where the seismograph installed in the three places does not operate and if the seismic acceleration is in the above range, an alarm is issued and the operation of the facility still continues.

Case B.

Seismic acceleration 0.25 m/s2 (25 GAL) or more and less than 0.40 m/s2 (40 GAL).

Only one or more alarms are generated by the seismograph. The seismograph are installed in the three locations. If the seismic acceleration is in this range, an alarm is issued and the operation of the facility continues. It shall be reported to the local fire department.

Case C.

Seismic acceleration 0.40 m/s2 (40 GAL) or more and less than 0.80 m/s2 (80 GAL)

If only one or more seismograph operates and if the emergency shutdown is used and if the seismic acceleration is in this range, an alarm is issued and the operation of the facility stops. Immediately set up contact with headquarters at Chiba Port Storage Facility and shall report to the local fire department.

In this case, accomplish external inspection for major part of pipeline and pressure decay rate check carried out when pipeline operation is stopped.

Case D.

Seismic acceleration is 0.80 m/s2 (80 GAL) or more.

The pipeline operation and the facility operation are immediately stopped by the seismograph and the set up the Headquarters for Response at Chiba Port Storage Facility. Also they have to report to their local fire department.

In this case, the pipeline pressure test is carried out for 24 hours after external inspection. Also during pressure test, external inspection is carried out again for major part of pipeline.

The pipelines are inspected and recovered after the earthquake.

In case the seismograph is at or more than 0.40 m/sec2 as 40 GAL; Visual check is performed for outline and leakage of the storage equipment and pipeline.

If no damages are found and no fuel leakage is observed via a visual inspection then the pipeline will be recovered for normal operation.

In case of accelerated energy, it is at or more than 0.80 m/sec2 as 80 GAL, check in accordance with following steps;

Step 1.

Visual check for outline and leakage of the storage equipment and pipeline.

Step 2.

If visual check is good and no evidence is found, shut-off valve except at 7 locations which needs to be kept opened and separated in 6 sections of the pipeline from Chiba Port storage to Narita International Airport.

Fuel settles and monitors pressure decay in the pipeline.

Step 3.

After verification of no evidence through Step-2, open 5 shutoff valves and pressurize pipeline with 1.25 times of normal operating pressure. In this condition, 2 shutoff valves at the pipeline ends are closed condition. Usually, pressurizes 3.6 MPa. (2.89 MPa normal operation pressure X 1.25 = 3.6 MPa)

The settling time is at a minimum of 24 hours and monitor pressure decay rate of the pipeline. When outside temperature changes it reduces pressure, pipeline pressure are reset again and it settles for 24 hours. Therefore, monitoring pressure decay rate will take time.

Step 4.

After verification of no evidence of contamination through Step-3, the pipeline activities resume to normal operation.

Estimate pipeline recovery time to this step is 72 hours after shutdown. But, this estimated time may change per working time in Step 3.

Figure 34-Visual Inspection for Joint Area in the Storage Facility

Figure 35-Visual Inspection for Valves in the Storage Facility

Inspection and Recovery after Earthquake for Airport Hydrant System

In case of seismic activity is between 0.40 and 0.80 m/sec2 between 40 and 80 GAL, then an inspection is carried out at the airport hydrant systems. However, the hydrant systems are continuing operating.

In case of seismic activity is between 0.80 and 2.00 m/sec2 as between 80 and 200 GAL, the hydrant system are manually shut-down and the fuel supply of the hydrant system stops.

External check for valve boxes and pits is carried out and at the same time pressure test is also carried out. When no evidence is observed, recover the hydrant system to normal operation. The down time for inspection is approximately 30 minutes in this case.

In case of seismic activity is at or more than 2.00 m/sec2 as 200 GAL, hydrant system is manually shut-down and the fuel supplied to the hydrant system stops. At first, external check is performed. If confirmed no damage on the hydrant system, pressure test is executed. Therefore, the down time for hydrant system may take longer in this step.

Recommendation

The occurrence of the earthquake cannot be foreseen definitely by anyone, neither the place nor the scale, but experts have foreseen the occurrence place from the structure of the geology and are able to know. It is an important task for the airport to always be prepared in case of an earthquake, especially in areas where earthquakes are predicted to occur. When an earthquake occurs, the phenomenon that the ground shakes, depending on the scale, everyone can panic and creates a chaotic situation.

In such a situation, in addition to periodic emergency response training, equipping the manual and equipment becomes important how calm and reliable correspondence can be made.

Naturally, the state installs and detects high-precision instruments that sense earthquakes, but I think that it is necessary for us to detect the earthquake early in the relevant airport and install the equipment on its own in order to take measures. Especially, installation of an emergency stop device linked with a seismograph can be said to be effective in minimizing damage, like fuel leakage. Maintaining fuel at the airport and maintaining refueling to the aircraft is to keep the operation of the aircraft and is extremely important in restoring the area after the earthquake.

Hope it will be helpful if the earthquake countermeasure at Narita International Airport becomes a reference, I hope the standardization of earthquake countermeasure equipment installation and standard creation at the airport will be done in the future.

Prepared by,

Aviation Fueling Department
Narita International Airport Co., Ltd.

Yukio Mashimoto
Manager
Airport Center, All Nippon Airways Co., Ltd.

PART V. BUSINESS CONTINUITY PROGRAM;

SEVERE DAMAGE BY THE GREAT EAST JAPAN EARTHQUAKE AND TSUNAMI AT SENDAI AIRPORT, AND BUSINESS CONTINUITY PLAN (BCP) FOR MEGA-EARTHQUAKE & TSUNAMI

Introduction

The Great East Japan Earthquake was a magnitude 9.0-9.1. It occurred at 14:46 JST(05:46 UTC) on Friday, March 11 2011, with the epicenter approximately 70 kilometers(43 mi) east of the Oshika Peninsula of Tohoku and, the hypocenter was under the ocean at a depth of approximately 29km(18mi). It was the most powerful earthquake ever recorded to have hit Japan, and the fourth most powerful earthquake in the world since 1900. The earthquake triggered a powerful tsunami, with waves that reached heights of up to 40.5 meters (133ft) in Miyako area in Iwate region, and in the Sendai area where it reached up to 10km (6mi) inland. The earthquake moved to Honshu (the main island of Japan), located 2.4m (8ft) to the east.

According to Japanese National Police Agency, there were 15,894 deaths, 6,152 injured, 2,562 people missing across 20 districts, as well as 228,863 people living away from their home. This was confirmed on March 10, 2015. The agency reported that about 127,000 buildings totally collapsed, 272,800 buildings half-collapsed and 750,000 buildings partially damaged on February 10, 2014. The earthquake and tsunami also caused huge and severe damage to the roads, the railways and at the airport (Sendai), as well as creating fires in many areas. The 4.4 million households in northeastern Japan were left without electricity and 15 million without water. The tsunami also caused nuclear accidents (Level 7 Meltdowns at three reactors in Fukushima Daiichi Nuclear Power Plant Complex). Sendai airport was closed until April 12, 2011 and restarted on and from April 13, 2011.

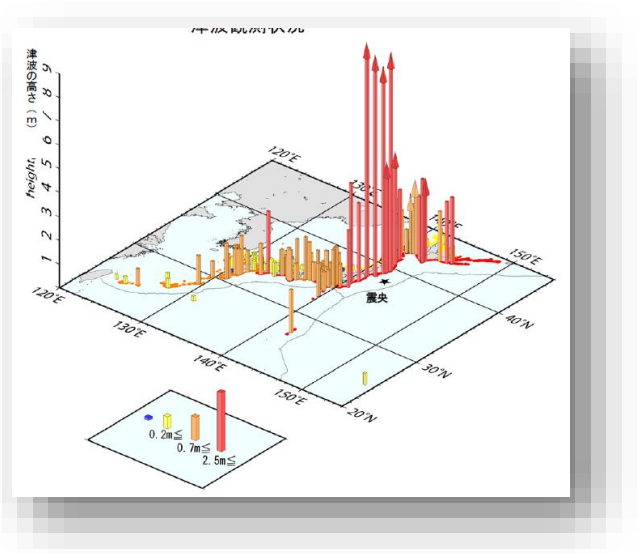


Figure 36-Wave height of Tsunami on March 11, 2011 by the Great East Japan Disaster

Tsunami

An up throughst of 6 to 8 meters along a 180-km-wide seabed at 60 km offshore from east coast of Tohoku resulted in a major tsunami that brought destruction along the Pacific coastline of Japan's northern islands. Thousands of lives were lost and the entire town was devastated. The tsunami propagated throughout the Pacific Ocean region reaching the entire coast of North and South America from Alaska to Chile. In Japan the tsunami warning issued by the Japan Meteorological Agency was the most serious on its warning scale; it was rated as a "major tsunami", being at least 3 m (9.8ft). The actual height prediction varied, the greatest being for Miyagi at 6 m (20ft) high. The tsunami indicated a total area of approximately 561 km2 (217 sq. mi) in Japan. The tsunami would have taken 10-30 minutes to reach the area first affected, and then areas farther north and south based on the geography of the coastline.

Just over an hour after the earthquake at 15:55 JST, a tsunami was observed flooding Sendai Airport, which is located near the coast of Miyagi Prefecture, with waves sweeping away cars and planes and flooding various buildings as it traveled inland. The impact of the tsunami in and around Sendai Airport was filmed by an NHK News helicopter, showing a number of vehicles on local roads trying to escape the approaching wave and being engulfed by it.

After earthquake and tsunami, some of area subsided up to 1.20 meter. The subsidence would lead another issue to be solved to avoid flooding problem or increasing risk to hit by high tide or next tsunami. Close to Sendai Airport, Iwanuma, and Miyagi Prefecture it was measured - 0.47m (1.54ft).

Severe Damage by the earthquake and the tsunami

1. Oil, Gas and coal disruption by the earthquake and tsunami

The earthquake provoked a fire to the 220000 BPD oil refinery in Chiba and to the 1145000 BDP Refinery in Sendai. It was extinguished after 10 days, injuring 6 people and destroying storage tanks. Others halted production due to safety check and power loss. Workers were evacuated, but the tsunami warning hindered efforts to extinguish the fire until March 14. In addition to refining and storage, several power plants were damaged. These include Sendai, New Sendai, Hiranomachi, Hirano and Hitachinaka.

2. Transport

Japan's transport network suffered severe disruptions. Many sections of Tohoku Expressway servicing northern Japan were damaged. The expressway did not reopen to general public until March 24, 2011.

A tsunami wave flooded Sendai Airport at 15:55 JST, about 1 hour after the initial quake, causing severe damage. Narita and Haneda Airport both briefly suspended operations after the quake, but suffered little damage and reopened within 24 hours. Eleven airlines bound for Narita were diverted to nearby Yokota Air Base.

3. Telecommunication

Cellular and landline phones service suffered major disruptions in the affected area. Immediately after the earthquake cellular communication was jammed across much of Japan due to a surge of network activity.

4. Severe Damage of Sendai Airport

Sendai Airport (SDJ) is main airport of the Tohoku area and there is 1,200 m and 3,000 m runway. Domestic airlines and various international airlines operate to the airport from Eastern Asian cities and Guam. The Aviation University is located in the premises of the airport and also, there are many general aviation aircrafts for training purposes.

The runway was closed soon after the earthquake occurred, and approximately 1,400 people of passengers, surrounding residents and staffs were evacuated in the Terminal building. At 15:56 JST on March 11, 2011, airport and related facilities were flooded by the tsunami. The Sendai airport terminal building was severely damaged and stopped all airport operations. The terminal building was flooded to a height of 3.02 m and lots of cars, debris flowed into the first floor of the terminal building. No airlines aircraft parked on apron at this moment but 67 general aviation aircrafts and helicopters were damaged by the tsunami.

Approximately 1400 people who evacuated from the tsunami and waiting for help and rescue. The vicinity of the terminal building had been flooded for a few days after the tsunami and there were continuous warnings for tsunami, therefore it was not possible to go out from the terminal for safety reason.

Flight operation at SDJ resumed on and from April 13, 2011 connecting to Haneda (Tokyo). On July 25, 2011 the airport resumed domestic flight regular service for the first time, after four and a half months. On September 25, 2011, the airport building was also fully restored, and the international scheduled flight restarted.

US military (Tomodachi-campaign) had a great contribution to clean-up runway and disposing of debris and damaged cars etc. in the early stage of the recovery.

Figure 37-Photo showing Tsunami spreading at Sendai Airport

5. Severe Damage of Sendai Airport Depot (Fuel Facility)

5.1 Outline of Sendai Airport Depot

Sendai Airport (SDJ) has a fuel facility owned by Pacific Co., Ltd. (PAC) The company provides fuel service as well. Four Japanese oil company supplied fuel from their refineries directly or through intermediate oil terminal faced to Pacific Ocean (Shiogama area). There is 980 KL capacity of two fuel storage tanks in the facility. PAC provides into-plane fuelling service using fuellers. There are three receiving bays and three fuel loading bays and a pumping station, a stock room to retain fuel samples and lubricants, emergency electrical generator room, office, gas station for GSE vehicles in this facility. PAC and fuel suppliers assign a total of 15 fuellers in this airport and about 100 KL of fuel supply to the aircraft per day.

Since no aircraft were parked on the apron at this moment, all staff of PAC worked in airport depot. .They followed the evacuation orders when the tsunami was announced by the fire authorities. First priority was to save the most human life possible, but it was also necessary to close the valve to prevent from spreading the spilled fuel from the storage tanks. The spilled fuel had a possibility to catch fire, as hybrid automobile sparked due to seawater invaded its battery.

On 15:56 JST March11, 2011, it was about one hour after the earthquake occurred, when a 20 m height tsunami arrived to east area of Sendai Airport. This tsunami wave could be recognized as a huge curtain over pine trees coastal forest. Some of the staff once thought to be last moment of their life, even when they had already evacuated the terminal building. The tsunami crushed, destroyed, killed, washed and flowed away any building, houses, trees, farm houses, life including people and everything else. As mentioned above, approximately 1 400 people were isolated for the next three days until seawater withdrew. Temperature at the time was low (almost zero at night) and with very limited food available for evacuated people. Seniors, infants and women who were expecting were given blankets and food. Most of the people who were sheltering at the airport were kept safe and warm, but the staff stayed in a cold open hall all through the night.

Figure 38-Photo showing flooding by the tsunami at Sendai Airport

5.2 Fuel Storage Tank

The tank is installed on a 0.65m concrete foundation with bund wall. It was submerged to height 2.4m from the ground level by the tsunami. The tank located backward from the sea, therefore the gas station blocked the wall, receiving bay and loading bay, pumping room, filter equipment, fueller would be working as a barrier to any materials that would collide with the tank directly. Fuel in the storage tank was not damaged by the tsunami and was on specification. This was confirmed by the recertification test based on the joint checklist. The aircraft was supplied with fuel and the airport resumed the flight operations. All fuel was withdrawn from the tank and then non-destructive inspection of the tank bottom plate was performed and welded repairs were done for the part where thinning of the plate thickness was found. In total degree of the two tanks was minor and repair part was minimal.

Figure 39-Photo showing huge volume of debris accumulated within fuel facility area

Figure 40-Photo showing less damaged tank and pipe and fell down steps

5.3 Fuel Receiving and Loading Bay

The damage of the fuel loading bay was severe. The fuel receipt had limited damages. This depended on the direction the tsunami hit and damaged where the fueller would be blocked or reduced the power of the tsunami to some degree. The fuel loading site, all the flowmeters and piping were wrecked. All hoses and

pipes with small diameter were destroyed, and in addition, the slop tank and the piped section were shattered. The damaged pipe was filled with seawater and of a reddish colour. Analysis showed severe microbiological growth by using IATA recommended test kit.

Figure 41-Photo showing severely damaged and debris accumulated at fuel receiving bay and loading bay

5.4 Filtration Equipment

There were two Micro Filters for fuel receiving and two Filter Water Separators for fuel delivery in the facility. The filters are located between pumping room and two storage tanks. Pumping room was severely damaged but it worked as barrier for the tsunami and guard these filters. A bed of pebbles, cobbles under the filters, were washed away by the tsunami but there were minor damage to the piping and filter vessel. However, the seawater entered the drain tank and the foundation was also found ruined. Fuel in filter vessels received a recertification test and it confirmed to be without damage.

5.5 Piping

Some piping were partly lost due to the influence of the tsunami; the remaining piping was also in a state of immersion in seawater, for a long period of time. Throughout the investigation, it was verified that microbiological growth in the pipes was existing where water remained inside. All pipes were removed and replaced or refurbished (sand blast treatment) at the manufacturer. Especially, pipes who became rusted due to the sea water. In addition, since the debris and sediment caused by the tsunami flowed into the pit where the piping was installed. It was necessary to start manually removing debris and sand.

5.6 Pumping and Electrical Station

Damages to the fuel transfer pump station and the electrical facilities were enormous. Most of the equipment were washed away by the tsunami. Not only the fuel storage facility but also the whole area around Sendai Airport. The electrical transmission tower collapsed due to the earthquake, and it was thrown away by the tsunami. Therefore the entire power transmission in this area had been stopped. Also, auxiliary power equipment and battery facility was lost. Since the debris caused by the tsunami flowed into the pits for electrical wiring installed in the fuel storage facility, it was urgent to eliminate debris, cobbles and pebbles manually.

5.7 Firefighting Facility

The firefighting facilities were all submerged by the tsunami. All fire extinguishing pumps were destroyed, a part of farm fire extinguishing pipe was lost by the tsunami, and other pipes were also covered with debris, cobble and pebble.

5.8 Fuellers

In Sendai Airport, four oil companies supply fuel to the storage and a total 15 fuellers were assigned at that time. The capacity of fuellers is 20KL, 12KL, 6KL, and 2 fuellers on the airport ramp on stand-by and 13 fuellers in the storage facility. The fuellers in the storage facility were destroyed by the tsunami, and 2 fuellers on the ramp were damaged by seawater by the tsunami. The tsunami reached about one hour after the earthquake, it was not possible to evacuate these vehicles to a safety zone out of the airport. Most of these fuelling vehicles did not have numbered plate to drive out of the airport, therefore it is impossible to drive away from airport based on compliance, and was jeopardizing human life. All fuellers became scrapped due to invaded seawater to the engine system and had a severe risk to catch fire. However most of the fuel in the tank of the fuellers carried out fuel quality recertification test by refinery laboratory and confirmed it was without problem to use for aviation fuel according to joint checklist. Some of tanks of fueller were damaged and invaded by sea water; this fuel with seawater was disposed off.

Figure 42-Photo showing damaged fuellers

Figure 43-Photo showing broken tank of the fueller at receiving bay to park.

5.9 Operating Office

Operating office was also severely damaged, flooded and had accumulated lots of debris by the tsunami. Walls in the office had huge holes and the glass windows were totally destroyed and the desks/chairs were scattered. All documents that remained in the office were damaged. They got wet by dirty sea-water that contained materials such as sands, soils, oils, bacteria, and etc.

Figure 44-Photo showing crushed vehicles and debris to the office.

6. Recovery work for Sendai Airport Fuel Supply

6.1 Cleaning-up

After the sea water was removed, the staff of PAC who were trapped for about 3 days in the terminal tried first to go home and to rest, or meet with family or search for missing family. PAC gathered the employees and started repairs. However, during the early stage of the renovation, it was extremely difficult to get to Sendai Airport due to the lack of public transportation system, or losing its own car and with a severe shortage of gasoline/diesel for automobiles until early April 2011. Even during the hard time, work for restoration started from searching the required documents such as regulations, qualification, RCQ/COA, training records and so on. As mentioned above, all documents were wet by dirty sea water. At first, staffs tried to remove debris, pebbles, sands, soils manually. However the huge equipment such as crushed vehicles, big pine trees could not be removed by human hands, therefore only smaller, lighter debris could be remove to other places and be disposed. Two (2) cars were crushed and remained within the office room. US Military brought heavy machinery as support to remove the large wreckage within Sendai Airport and airport Depot.

Fuellers could not be used for fuelling because they were filled with sea water into engine system. They remained at the airport depot until fuel in these fuellers were withdrawn. Relocating some fueller from other airport by following defueling procedure and which permitted to supply other fueller. At the end all the fuel found in the fueller was consumed. These fuelling vehicles were scrapped. On April 13, 2011 flight operations resumed but limited number of aircraft were ordered to supply fuel. The first few weeks were mainly to supply helicopters. During these days, a lot of earthquakes occurred including tsunami warnings, therefore most of the fuel operation was full tankering.

6.2 Fuel Supply Chain

The aviation fuel supply chain was disrupted due to severe damage of the earthquake and tsunami. Sendai Airport operation was completely stopped until April 13, 2011. For surrounding airports, it was difficult to continue to supply jet fuel, because the intermediate oil terminals facing the Pacific Ocean were damaged and needed repairs. Therefore Jet fuel was supplied by Niigata, Chiba to continue flight operations. One of intermediate oil terminals had almost no damage due to a relatively high attitude with high bund walls, and was backwards to Matsushima islands. This reduced the strength of the Tsunami. Even lots of floating material covered the sea close to the oil terminal. The government (JCG) had high priority to remove these floating materials to resume uplifting oil products from other area. It took an enormous amount of time for the airport to be supplied with jet fuel. It had a minimum amount of oil products, therefore the oil terminal delivered

gasoline, kerosene, diesel etc. Three other suppliers of the oil terminal had damage with some difficulties to upload and deliver oil products.

6.3 Fuelling before Airport facility full restoration

None of the fuellers could be utilized due to severe loss caused by the tsunami. Alternative fuelling vehicles were collected from other airports by suppliers. At this point, since the fuel supply to Sendai Airport was not restored and the supply of fuel left in the storage tank and fuelling vehicle tank passed the recertification quality test at the laboratory and utilized. Fortunately, there was a great quantity of fuel remaining and no sea water contamination was observed. There were enough fuel to hold until the fuelling system was restored. With the permission of the local fire department authorities, the fuel was transferred between the fueller via the fuel filters that were working as in the same way as the fuel facility filters, even without electricity.

After having consumed all fuel in the damaged fuellers, these were then disposed and moved to a scrap factory. This increase the work space for repairing. The remaining fuel were stored in two storage tanks.

The storage tanks were installed with temporary outlet valve and adaptor to be connected by reel hose of the fuelling vehicle to receive fuel. The methodology of receiving fuel from storage tank was almost the same. Electricity system was recovered, but fuel facility piping was not yet repaired, therefore using the fueller as fuel facility was continued until full recovery of the pipe system.

A temporary operational procedures was that the fuel from a road tank car was received by fueller directly, and with the approval of the local fire department. The procedures also were applied until partly recovered of the fuel receipt and supply system, without delivering it to the storage tank by using a recovered or replaced pump. After delivering all fuel to one tank, a non-destructive inspection was carried out. Since a concern was found in a section, welding repair had to be done. Another tank received the inspection and Sendai Airport fuel facility was completely restored in November 2011, eight months after the earthquake occurred.

6.4 Fuelling and Facility Company contribution to restore operation

There were no deaths at PAC caused by the earthquake and tsunami. The only exception was one staff left the company to relocate into another area His wife was feeling scared above a constant threat of additional earthquakes. However, all other staff wished to continue working at PAC and they were officially accepted. During the time, PAC's income was very limited and needed to make a great investment to restore their facility to continue their business. PAC's contribution to restore their fuelling business was of great need and importance to keep their employees. After recovering the fuel facility and restarting the fuelling service, the demand of fuel supply increased. If PAC was not able to keep their staff, it would have not been possible to operate and supply the demand due to the lack of skilled and well-trained fuelling and facility personnel,

7. Lesson from the earthquake and tsunami

Japan is an earthquake-prone country, In addition to daily preparation in case of an earthquakes, regular training is also conducted by company and local government. Strict standards are imposed on all buildings including fuel storage tanks under the Building Standards Law of Japan. It is nearly impossible to predict a huge earthquake and tsunami like the Great East Japan Earthquake. Nobody could have expected that a huge tsunami of a height of 20 meters was going to attack.

After experiencing this disaster, PAC re-examined the facilities' equipment and document management. Since the tsunami carried many things, such as automobiles, timber and debris from the collapsed houses, it was important to prevent them from directly colliding with the fuel tanks and the other facilities. It can be said

that the protective fence is effective against the direction of flow to prevent direct influence of the tsunami. It is also necessary to evacuate and elevate the fueller to a safety location. There are limited areas where you can evacuate if the surface is flat. This is the case of the airport. In addition, there are many GSE vehicles besides fuelling vehicles making this difficult for circulation. However, it becomes difficult to find an effective protection system against a huge tsunami, especially that a company cannot deal with it alone. Towards the end of the reconstruction of the aircraft fuelling systems, it became an obstacle to restore destroyed documents. For these reasons, important documents such as the Regulations and Qualification Certificates are kept in electronic format. There are documents used exclusively in case of emergency. Such effective countermeasures are also provided to the airport fuelling facilities nationwide and are being followed as such.

Another problem and concern is the reuse of fuel remaining in tanks and the fuelling vehicles. In the case where the supply routes were discontinued, it was a priority to start with the reconstruction of the airport of areas touched by the earthquake. For that purpose, it is necessary to use the fuel that remains in the facility and in the fuelling vehicles. Upon resuming of fuelling operations, we sent the fuel sample to the supplier's approved laboratory. They were tested and confirmed free of contamination, even though it was difficult to perform the tests.

8. Business Continuity Plan for mega-earthquake and tsunami

Due to damage and experience of the Sendai Airport fuelling facility by this natural disaster, suppliers and their associations as PAJ, Petroleum Association of Japan developed the BCP (Business Continuity Plan) in order to quickly resume business activities. The "Guidelines for Aviation Fuel Quality Control & Operating Procedures (PAJ Guideline)" was issued in January 2017 as the 12th edition, complying with JIG 12 and local regulations. The guideline included new part that dealt with emergency response.

The emergencies manual is composed of:

(1) Earthquake and tsunami emergency procedures for fuel facility, fuelling vehicle, office damage and destroyed documents, fuelling system in case of emergency,

(2) Fire (small scale), inside of filter vessel, no injection/injection of fire extinguishers used from the fuel farm up to the storage tank, and in a situation of repairs may take a long period

(3) Fuel supply disruption and contaminating incidental materials and

(4) Other irregular cases such as electronic power shutdown, road closures by traffic accident, heavy snow, land slide, abnormally low of conductivity of jet fuel and doubt of effect by radioactive materials.

The purpose of the emergency response guidelines is to provide proper handling and fuel quality control for aviation fuel in case of an emergency such as earthquake, tsunami, fire etc. The emergency response guidelines aim to set up industry standards for receiving, storing, delivering of aviation fuel in advance. In case of severe damage by a huge earthquake and/or tsunami, large scale fire, even the fuel facility could be partially or completely destroyed and unusable. If fuel remains in the storage tank or the fueller, it requires a recertification test from an approved supplier laboratory. It would be possible to supply fuel, after relocating the fuelling vehicles from another airport, or by using the fueller at an operating fuel facility or by defueling from a damaged fueller or storage tank. In the case where the standard is being applied, it may be necessary to prior discuss with the relevant authority (as firefighting office). Shortage of jet fuel can be expected, so there is a possibility to request that airlines need to tanker to save fuel.

8.1 Earthquake and tsunami

After a mega-earthquake/tsunami occurs, it is apparent that the first priority is saving lives. If possible, closing valves of receiving and delivering pipes is recommended to prevent from widely spreading fuel from broken pipes. The closing of the valve operation is quite important, because a damaged hybrid vehicle that has a strong battery and which also has water infiltration may trigger sparks and, provoke an explosion. If aviation fuel spreads over its surrounding area, water with fuel would spread easily and possibly reach the airport terminal /building where the people were evacuated. Considering this the deadliest scenario possible at an airport.

In addition and if possible, it is recommended to contact the supplier, the fuel facility owner, the airlines and the airport authority. When evacuating from the fuel facility, bringing an emergency pack that is prepared in advance is highly recommended. The contents of the emergency pack should include food, water, rain coat, gloves, towel, light, whistle, battery, and electronic media of important documents and shall include a contact list of staff and their family.

8.2 Fuel facility

Handling of fuel in storage tank

After the mega-earthquake and tsunami occurred, it was easily expected that communication would be difficult. The challenges where to connect and get the approvals by related airlines, suppliers, fuel facility operating companies/owners, fuelling companies and airport authorities and so on.

In case of encountering severe damages of the fuel facility by earthquake and tsunami, the possibility of fuel leak should be checked. If the facility confirmed a fuel leak, investigation of the fuel spreading area and the amount of fuel loss, should be as precise as possible. Checking the degree of damage of the fuel facility equipment is thought to be next step. Then it will be determined if this equipment can be reused or disposed.

In case of an invading tsunami within bounded wall of the storage tank, it is essential to carry out a recertification test by an approved supplier laboratory, to confirm whether the fuel can be reused or not. It is also important to check the risk of sea water penetration into storage tank. If the recertification test result suggests failure to confirm its quality, the fuel shall be disposed or used for non-aviation fuel. If the recertification test result confirms free of contamination status and if it meets the joint checklist requirements, then the following procedures are recommended.

If the filter water separators are possible to utilize, the fuel should be delivered through the filters. Inspection for these filters and checking the degree of damages, visual check should be performed and a recertification test is recommended to confirm its integrity. If the filters are damaged and pipes recognized, the filters shall not be used. In such case a temporary outlet valve is fitted with an adapter to receive fuel from the storage tank. The fuel in storage tank is received by fueller. The fueller can be treated as fuel facility and filtration equipment, the fueller is possible to deliver fuel to other fueller.

Case for the fuel facility is completely damaged and inability to use

In case of pipes are severely damaged and it becomes very difficult to deliver through the fuel facility, lots of limitation have to be considered. If there is no evidence of sea water invasion into storage tank and/or fueller, the fuel should be supplied. Consuming the fuel that is supplied to aircrafts, it means decreasing the stock level. Resumption of fuel supply by road tank car is essential to continue fuel supply to the aircrafts as ordered. If receiving by road tank car is applied, once fueller is receiving fuel from the road tank car and delivering other fueller. In this situation, the intermediate fueller worked as fuel facility and filter as mentioned above. However, the procedure is to get the approval by fire-fighting office who is located at the airport. If it

is impossible to move enough fuellers from another airport and it is hard to use the fueller from the fuel facility and/or filter, the fueller received fuel from the storage tank, fueller and road tank car and supply to aircraft without the proper permission of related company including airlines and/or authority.

Case of invasion sea water into damaged pipe

If there is a risk that sea water enters the broken pipes, a microbiological growth test shall be performed. If the test result shows positive, it is necessary to perform flushing. The sand blast treatment for pipes shall be carried out or pipes replaced. In addition, filter elements should be exchanged if necessary. In case of sand blast treatment and filter element exchange, there is a risk of decreasing conductivity rapidly by absorbing SDA to refresh the pipe wall or new filter elements, therefore measuring conductivity is recommended. There were a rapid decreased, (less than 50 pS/m of conductivity), experienced during the repair period at Sendai Airport fuel facility. If this phenomena occurs, a high conductivity of fuel should be mixed or added, and then confirm at least 50 pS/m conductivity following JIG Bulletin protocol in case of low conductivity or AFQRJOS checklist. If user grants permission to receive low conductivity fuel (25-49 pS/m), the fuel is possible to supply. If the conductivity of the fuel fails to increase to 25 pS/m, the fuel shall be mixed or added with a high conductivity of fuel again, or disposed of.

Case for fuel supply during repairing

Repairing work of the fuel facility is progressing when receiving and delivering facility restarts, uploading directly from road tank car stops, resume to use filters of the fuel facility and deliver to fueller. If the tank is still under repair or under inspection after completion of repair work, then storage in tank is not possible. Therefore receiving aviation fuel from road tank car and delivering to the fueller via filters without storage in tank is required.

Inspection of completion of repairing

During the tsunami, if the sea water fills the bounded area of the storage tank and goes beyond the level of the bottom of the tank, there is a risk that the sea water filtrates the basement of the tank and that the sea salt remains. These possible remaining salts have the possibility to promote the corrosion of the bottom plate of the tank. Regular inspection, at least 3 years interval, including non-destructive test to measure thickness of the plate shall be carried out. Ensure the responsibility of the fuel facility performs a daily and regular checks. If there is a lack of proper dataset, it shall be treated as a finding during inspections by airlines, suppliers, and authority.

8.3 Fueller

Cases of the degree of damage for fueller

8.3.1 If the sea water by the tsunami does not reach the piping level of the fueller and the vehicle can drive without any problem, the fuelling vehicle is washed to remove any salty soil, debris etc. and then goes back to fuelling service after checking the condition of fueller.

8.3.2 If sea water enters the engine, it should be regarded as damage and it is out of order. Therefore the fueller cannot be used for fuelling service. Proper overhaul repairing work should be required to use fuelling service again.

8.3.3 If sea water reached the parts of electronic control system, a risk for catching fire shall be considered. Therefore repairing work has to be performed and even if it looks like there are no damages, it is not recommended to use the vehicle again.

8.3.4 In case of relocating of fuellers from another airport, proper documents shall be prepared and applied to related authority to use the fuellers.

Handling of the fuel in tank and pipes of damaged fueller

In case the sea water reached the tank bottom valve or pipes, a risk of infiltrating sea water into the tank or pipe of the fuelling vehicle is expected. Hence appearance check and recertification test by an approved laboratory of the fuel shall be carried out. If applicable, the fuel in pipe should be drained out. If there is a clear evidence of sea water found in the tanks or pipes, via holes or tears of the tank wall or pipe, the fuel in the tank or pipe shall be disposed adequately. Even if it is decided before hand to dispose the fuel, we shall wait for be a professional company treating industrial waste who can perform recovery or disposal work. During the time the fuel is to be transferred to proper drums, ISO containers or temporary tank that is not damaged or have no risk to leak or produce a high quantity of hydrocarbon vapours from the viewpoints of environmental issue and decrease the risk for catching fire.

In case of passing the appearance check and recertification test at an approved laboratory of the fuel, a usable fueller that is relocated or repaired without no risk on catching fire, using the reel hose by following defueling procedures, and then the fuel can be delivered to another usable fueller that can supply the fuel to the aircraft. The fueller that received and supplied fuel to the other fueller acts as a fuel facility or a filter instead of the damaged fuel facility until it is repaired. The documents of the appearance check and recertification test results shall be kept by facility operating company properly.

Security of the fueller

In case of severe damages of the fence surrounding the fuel facility, security for the fuelling vehicle and for the fuel in fueller shall be taken into consideration. It is expected that it is almost impossible to build a new fence immediately after a mega-earthquake and a tsunami. There is a possibility to park the fueller within the airport such as the ramp area. The temporary fence is built by the airport authority before resuming airport operation. It is based on our experience during the repairing at Sendai airport, fuellers usually park in the parking area of the facility. It would be worthwhile to ask or discuss with airport authority to get approval prior to park at the airport. Parking these fuelling vehicles within the airport should be safer than within the fenceless fuel facility.

Severe damage of operating office and destroyed important documents

Any important documents should be prepared and saved under an electronic media, ensured that it is easily accessible and safeguarded or kept in the evacuating area in case of emergency by using the emergency pack. If the important documents are kept in the electronic format, resumption of fuel facility and fuelling service operation would run much smoother by reproducing or reprinting documents if necessary.

If there is no such electronic media available, these important documents including a hard copy shall be provided by the user to the related company or contracted company. These main documents contains regulations, contracts, qualification certificates etc. that are essential to the maintenance before resuming operations of the fuel facility and fuelling service.

In case the documents are flooded by the tsunami, they are considered to be polluted by sea water containing bacteria or germs that usually inhabited within soils, sea waters etc. Therefore even the remaining documents which are still readable should be copied.

Fuelling pattern in case of emergency

Many rescuers, police, fire-fighters, media helicopters and cargo flights which brings goods such as foods, drinks, blankets and cloths arrive at the disaster area around the airport and its surroundings. Pistol type nozzle adaptor or fueller equipped with pistol nozzle should be assigned at the vicinity or within a high risk area of occurring mega-earthquake and tsunami as soon as possible.

In addition, various fuelling operations are required continuously starting immediately after the mega-earthquake and tsunami and up to 3 to 4 days after in order to save human lives, to bring relief materials and to transfer seriously injured people to a hospital out of the disaster area. More than 5 days after the disaster, rescue and media flight operations decrease rapidly but there are still a lot of fuel requests being received. It can be expected that most of the fuelling staff are in total exhaustion, especially for the local airport where fuelling supply is done by a few staff available with no supporting workforce for a long period of time. They keep supplying and receiving lots of request simultaneously. Therefore back up system, as receiving staff support from other airports as replacements so that the fuelling staff can rest, should be required. In addition, enough drinking water, food and fuel for automobile to commute to work should be stored for emergency. The gasoline for vehicle of workers at the airport also is also a huge issue to be solved. The airport made an arrangement of distributing fuel tickets up to 20 L gasoline at one of gas station close to Fukushima Airport. This turns out to be effective. However, people who were living in the surrounding of the airport complained to the gas station staff of the severe shortage of this type of fuel.

Best practice for preparation of emergency response

PAJ developed the emergency response system and provided them as a recommendation to be incorporated within the PAJ guidelines. Effective evacuating routes and gathering points in case of emergency such as earthquake, tsunami and fire are recommended to be displayed clearly in the office, as well as to be documented. To be prepared in case of an emergency, all fuelling and facility staff shall be familiar with the emergency response and procedures. Training and drill for the emergency response is required to be performed smoothly, effectively and adequately. Outline of the emergency response guidelines and responsibility of each staff shall be displayed in the office to reconfirm it. Training of contacting the proper person, this includes people who work for a third party company, during a simulation of an emergency shall be performed. The training records shall be kept properly. If possible, a joint training and drill with the fire-fighting authority or airport authority should be carried out. The list of participants of these trainings and drills shall be written and kept in a document. If necessary, management, new employees, transferring staff, contractors and visitors shall be informed of all effective evacuation routes and gathering points.

PAJ guidelines require to perform the following actions in case of assuming the mega-earthquake and tsunami;

a. Heavy weight materials such as documents, hydrant pit valves etc. shall not be stored on the higher shelves, that is, there is a risk of falling down to floor or on top of staff, it can lead to serious injury.

b. Shelves, lockers and cabinets should be fixed and equipped with wire or chain to prevent from falling down.

c. Fragile materials as glass or products shall be stored on the shelf as low as possible to prevent it to break and lead to injury.

d. Emergency packs shall be prepared and include all necessary goods to survive and all important documents via USB to facilitate the resume of operations.

e. Airports that have a high risk to be affected by tsunami, must follow the below actions as emergency response should be followed;
   - Confirming effective evacuating route and gathering point.
   - Collect all safety information of confirmed staff and their family.
   - Ensure the measures to communicate effectively such as satellite phone.
   - Prepare the emergency pack to carried out from the office

Proper methodology of important documentation should be taken into consideration as well.

Developing a BCP of the relevant fuel facility and fuelling company is recommended.

Develop the BCP at an airport considered as a high risk area who's facing the ocean and with a flat coastal area, which has no protective barriers from a tsunami that occur after a mega-earthquake.

8.4 BCP developed by JCAB

Japan is known to be a country with one of the most active and re-occurring earthquakes. Recently some seismologist point it out the high risk of huge grade earthquake in Tokai, Tonankai and Nankai districts. Historical records also suggest a repetition of huge earthquake and tsunami occurring. These records of huge earthquake after Edo era (after 1603) remains such as Keicho (1605, estimated magnitude 7.9-8.0), Houei (1707, magnitude 8.4-8.6), Ansei (1854, magnitude 8.4), Showa Tonankai (1944, magnitude 7.9-8.2) and Showa Nankai(1946, magnitude 8.0-8.4).

Recent research of simulation of tsunami height from Tokai district to Nankai district shows a 6 m at Chuubu, 16 m at Nanki-Shirahama, 4.6 m at KIX, 4.0 m at Kobe, 6.2 m Tokushima, 16 m at Kochi, 4 m at Matsuyama, 4 m at Ube16 m at Miyazaki and 11.6 m Naha. Tokyo area is also known as a high risk of earthquake. It is called a large scale earthquake that occurs directly underneath the Metropolitan region.

JCAB (Japan Civil Aviation Bureau) developed the Recovery Plan for 5 airports facing the sea such as Sendai, Haneda, Kochi, Miyazaki, and Oita in order to save human lives and restore the airport functions. In order to resume airport function at an earlier stage, JCAB set up a working group including experts as university professors to discuss how to achieve early restoration of airport function. The area is focused at Sendai, Tokyo Bay area, Tokai, Tonankai and Nankai district as mentioned above.

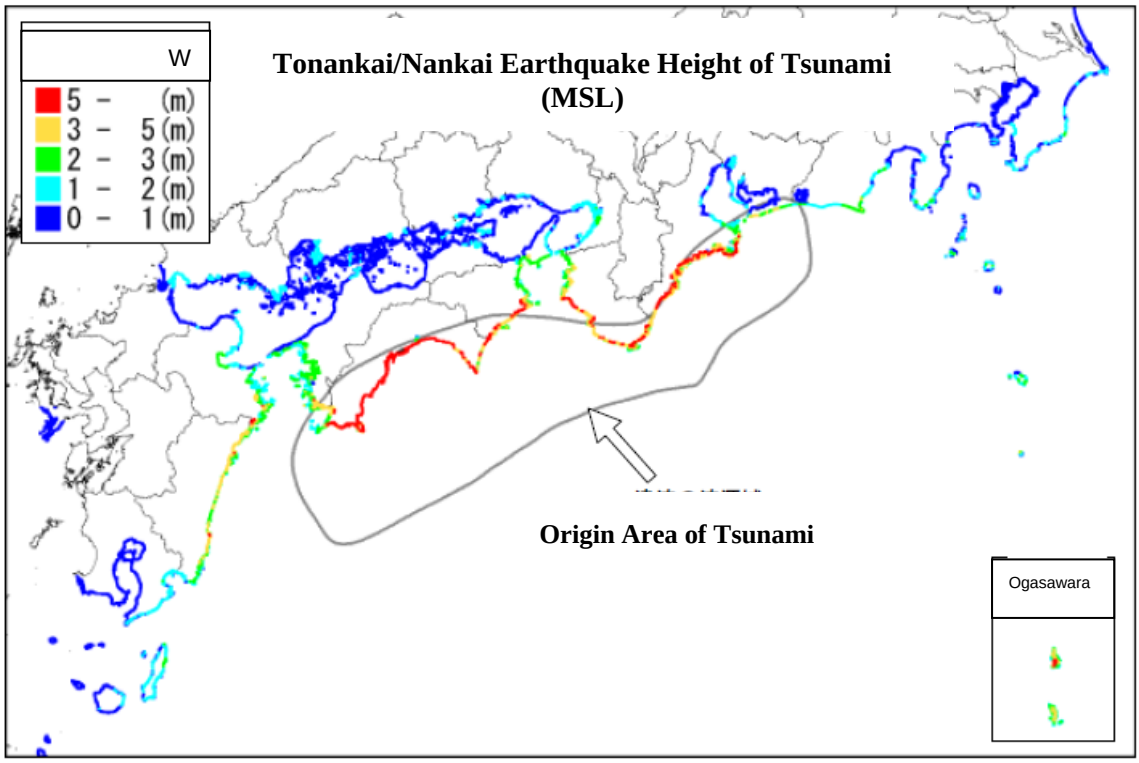


Figure 45-Estimated wave height of the tsunami in case of Tonankai/Nankai earthquake

Fuel Facility Company and fuelling service company have a major duty to provide jet fuel to helicopters, cargo flight and passenger flight and supply diesel for GSE vehicles as well. Large size debris such as damaged cars, pine trees, debris of house fragments is impossible to be removed. Therefore the request for removal of these huge debris to have access and space to receive fuel at fuel facility is repeatedly discussed, because private company cannot perform cleaning work without the heavy machinery. JCAB understood its importance to supply jet fuel to aircrafts as early as possible.

Agency of Natural Resources and Energy (METI) is based on “BCP for each oil company” and some cooperation is needed with other oil company to set up effective supply chain for all petroleum products. The Japanese government regarded fuel facilities at airports as important facilities to uplift aviation fuel to aircrafts to save human lives. The fuel facility is treated as the base for human life saving using helicopters. In case of a huge earthquake and tsunami, the agency requests PAJ to supply jet fuel to nominated airport as a base for saving human life. PAJ requires aviation fuel supplier to deliver enough volume of fuel to uplift. The small portion of aviation fuel at Fukushima airport was delivered from another supplier as emergency action to maintain fuel quantity which requested by government in March 2011. Some airports located far from the coast and are without any risked to be engulfed by the tsunami are appointed as regional bases in case of a disaster. The regional bases are Shizuoka, Komaki, Kumamoto. Other airports considered as candidate centres relief in case of a disaster. Road tank can be used as emergency transportation vehicle for goods and it is possible to use the highway that is restricted for the public. Mitigation of driving through a restricted tunnel is also discussed to transport fuel effectively in case of emergency.

PAJ set up BCP Task Force to discuss the effectiveness of providing fuel supply in case of an emergency. Case studies show that such damages experienced at Miyazaki Airport, Oita Airport, Kochi and Tokushima Airport were vital for the lessons learned. Some back up airports could be Kagoshima, Fukuoka and Takamatsu for Kochi and Tokushima. If the receiving aviation fuel of the fuel facility were to stop, the fuel

supply for rescue helicopters and cargo flight could bring relief goods regards as first priority. The flight from another area where there are no damages by the disaster should be requesting tankering operation to maintain fuel capacity. Cooperation between oil suppliers is also discussed. In case of a tsunami the possibility of evacuating the fueller to a safe altitude area, close to the airport, is also discussed with the airport authority and the local police. The main reason is that the fueller does not have a number plate due to its heavy weight and, are using it within the airport with the exception for asking repairs to the vehicle. Three Pistol nozzles for use in case of an emergency were provided to Kagoshima, Takamatsu and Haneda to support the uplift of rescue helicopters. PAJ continuously supports the development of the BCP at the airport and are also in constant discussion with the local government

Prepared by,

Takeo Tateishi
Senior Manager, Petroleum & Coal Marketing Department
Idemitsu Kosan Co., Ltd.
Chairman of Joint Guideline WG, Aviation Committee, PAJ

Shin Onodera
General Manager, Aircraft Refueling Department
Pacific Co., Ltd.

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to order : International Air Transport Association

www.iataonline.com

custserv@iata.org

+1 800 71 66 32 60

+1 (514) 874 9659

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