CHAIRMAN’S CONSOLIDATED REPORT

From : MAR ROXAS
    Secretary, DILG;
    Chairman, IATF

Subject : TWO SERENDRA EXPLOSION INCIDENT INVESTIGATION REPORT

Date : SEP 05 2013

Following hereunder is the Chairman’s report on the investigation of the Two Serendra explosion incident.

It takes into consideration the investigative work done by: (1) Philippine National Police (PNP); (2) National Bureau of Investigation (NBI); (3) Bureau of Fire Protection (BFP); (4) Inter Agency Anti-Arson Task Force (IATF); (5) Department of Health (DOH); (6) Department of Science and Technology (DOST); and (7) Department of Public Works and Highways (DPWH) individually, and, as each may have been adopted, in either their entirety or in portions, in the investigation of the IATF - Composite Team led by F/SSUPT Fennimore V. Jaudian. A copy of the report is attached as Annex 1.

It also takes into consideration the parallel investigation and review undertaken by the independent firm of Kroll Associates (S) Pte Limited, in particular, the team of experts headed by Mr. James William Munday. A copy of the Kroll report is attached as Annex 2.

This report will be submitted to the following government agencies for their appropriate action:

<p>| 1. Department of Justice (DOJ) | To make the necessary determination if there is any liability, whether civil or criminal, for acts or omissions of the persons implicated in the explosion. |</p>
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<tr>
<th>2. DILG, DOE, DTI, Bureau of Product Standards (BPS)</th>
<th>To adopt or formulate the following standards/guidelines: Standard for Gas Leak Detector; Maintenance Guidelines for Liquefied Petroleum Gas (LPG) Detector; and Standard for Vaporizer Machine and LPG Vapour State Distribution System.</th>
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<td>3. DILG, DOE, DPWH</td>
<td>To review the existing Memorandum of Agreement (MOA) or execute a new MOA between DILG, DOE and DPWH regarding the conduct of joint inspection of LPG farm/facility, all Serendra buildings and other buildings/establishments within Bonifacio Global City utilizing centralized LPG vapor state distribution system, and the piping system layout of Bonifacio Global City to avoid similar occurrence in the future.</td>
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| 4. BFP, City of Taguig/Other LGU Building Officials | - To conduct a comprehensive review of existing buildings using centralized pipe-in LPG system and any alterations to the piping system layout.  
  - To adopt international standards and best practices involving the use of some safety features not currently present in Bonifacio Global City and Two Serendra Installations.  
  - Develop a national regulatory framework for the design, installation and use of piped LPG vapor and other fuel gas systems based on international standards and best practices. |
| 5. DPWH, LGU Building Officials                      | Develop a national model framework for the design, installation and use of piped-in LPG vapor and other fuel gas systems to be adopted by developers based on prescribed design construction guidelines of residential condominium buildings and residents thereof based on prescribed guidelines to be adopted in House Rules and Regulations. |
Subject: TWO SERENDRA EXPLOSION INCIDENT INVESTIGATION REPORT

I. INTRODUCTION

On 31 May 2013, at approximately 7:59 p.m., an explosion took place in Unit 501-B, Section B, Tower A, Two Serendra, McKinley Parkway Drive, Bonifacio Global City, Taguig City. The blast resulted in the deaths of four (4) persons, namely: Salimar Natividad, Jeffrey Umali and Marlon Bandiola, the driver and passengers of an Abenson delivery van that was hit by a slab of concrete wall which was detached from the building by the explosion, and Angelito San Juan, the occupant of Unit 501-B who suffered burns and died on 04 July 2013 in addition to causing several injuries and damage to properties.

These deaths, injuries and damage to properties were the consequence of a fatal combination of several factors, including, among others, negligence, reckless disregard of the rules, outdated regulations, lack of or inadequate standards and human error.

This report establishes the sequence of events leading to the explosion, the cause of the explosion, and the acts and omissions of certain parties whose culpability is more properly to be judged by the DOJ in a preliminary investigation for purposes of determining probable cause on whether or not criminal charges should be filed with the court.

The report also proposes recommendations on the strict enforcement of existing regulations, as well as the amendment/modification of certain regulations, including the adoption of international standards and best practices to avoid similar incidents in the future.

The results of the investigation concluded that the explosion in Unit 501-B was directly caused by the ignition of escaped Liquefied Petroleum Gas (LPG). The escaped LPG came from a detached or improperly connected black braided flexible hose intended to supply gas to the cooking range.
In sum, the explosion resulted from a combination of circumstances, including, but not limited to, the following:

1. Detachment of the flexible hose (supplying LPG to the unit) caused by the transfer of the cooking range by one or more persons during the renovation which went beyond the Scope of Works disclosed to and approved by the Serendra Building Official;

2. Return of the Unit to the owner and/or its authorized representative after renovation without the Serendra Building Official's inspection and certification, which would have discovered any unauthorized, defective, faulty or unsafe work done during the renovation;

3. Allowing the wrong (i.e. not specifying the correct) in-unit safety devices to be installed, such that these were inoperative when the time came for these safety devices to function. Safety devices were rendered non-functional because (1) the automatic shut-off valves connected to the leak detectors were of the plug-in/plug-out type and (2) they were of the “normal-on/fail-open” design which would only close electrically upon receiving a signal from the detector;

4. Building design factors which lacked a mechanism or system to detect unusual and substantial utilization of gas which should lead to an automatic shut-off;

5. Failure of the building management to strictly impose and/or enforce restrictions in accessing the gas valve in the meter cabinets, and allowing an unauthorized person to reinstate the gas supply to the Unit;

6. Lack of technical competence of the gas supplier about odorant processes in LPG, particularly, the possible loss of the odorant additive ethyl mercaptan during the vaporization stage of the LPG before it is supplied to the Bonifacio Global City centralized pipe-in LPG system;

7. A culture of indifference (bahala na, ok lang attitude) bordering on negligence by all parties (RM Ladrido Construction Services,
Two Serendra, Inc., Bonifacio Gas Corporation, Makati Development Corporation, the residents) when dealing with centralized pipe-in LPG system which is a technology relatively new in the Philippines, involving a very delicate and readily ignitable combustible chemical substance, like LPG. In short, they could have exercised greater due diligence and a sense of fiduciary responsibility in the performance of their functions.
Background

Serendra is a prime residential project located in a 12-hectare development estate, owned by Serendra Inc. and developed by Ayala Land Inc. Serendra is divided into three (3) main districts, namely: One Serendra, Two Serendra and Serendra Retail located between 11th Avenue and Mckinley Parkway, Bonifacio Global City, Taguig City.

Particularly, Two Serendra District is a residential condominium project divided into five (5) sections: Sections A, B, C, D and E. Each section is composed of clusters of towering multi-level buildings sharing common basements.¹ Sections A, B and C of Two Serendra were constructed by Makati Development Corporation as the general contractor.

¹ Detailed information on Serendra is contained in the IATF - Composite Team Report, attached as Annex 1.

Figure 1. Serendra Map
Section B, Tower A, where Unit 501-B is located, is a seven-storey structure composed of thirty-five (35) residential units, having five (5) units per storey.

Figure 2. Section B, Tower A Layout
II. THE INVESTIGATIONS

The initial investigation by the PNP, NBI, and BFP concluded that the explosion was not caused by a bomb, whether improvised or manufactured, or any secondary device.\(^2\)

On this basis, IATF\(^3\) formally assumed jurisdiction over the investigation to determine the cause of the explosion.

The conduct of a fact-finding investigation\(^4\) by the IATF - Composite Team with the PNP and BFP as support groups, was pursuant to the directive of the Secretary of the Interior and Local Government (SILG) in Mission Order No. 06-2013-01 dated 03 June 2013, and the following coordinating instructions from President Benigno S. Aquino III to coordinate and/or tap DOH, DOST, DPWH, NBI-Counter Terrorism Division and other Agencies to assist in the investigation.\(^5\)

On 02 July 2013, DILG recommended to the President the engagement of an international expert in gas explosions considering that centralized pipe-in LPG system is a technology relatively new in the Philippines and there are no available local experts who are experienced in forensic investigation of LPG explosions, to assist the IATF - Composite Team in the ongoing investigation. For this purpose, the engagement of Kroll Associates (S) Pte Limited\(^6\), a Singaporean company, which is affiliated with Kroll Advisory Solutions (Kroll), was recommended, with Mr. James William Munday\(^7\) leading the team of experts in gas explosion.

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\(^2\) A summary of the investigation conducted by the PNP, NBI and BFP is provided as Appendix A of this report. The details of the investigation, and the names and credentials of the experts are all contained in the IATF - Composite Team Report.

\(^3\) The qualifications/credentials of the IATF - Composite Team are provided in Appendix B of this report.

\(^4\) Presidential Memorandum Order No. 371 dated 15 May 1996 created IATF - Composite Team “to conduct speedy investigation of suspicious fire incidents in government offices and heavily-insured private buildings, immediate apprehension of suspected arsonists and fast disposition of arson cases filed in court”, a copy of which is attached as Appendix C.

\(^5\) A summary of the investigation/examination/tests conducted by IATF - Composite Team and particular government agencies is provided in Appendix D in this report. The details of the investigation, and the names and credentials of the experts are all contained in the IATF - Composite Team Report.

\(^6\) A summary of Kroll Associates (S) Pte Limited’s qualifications is provided in Appendix E of this report.

\(^7\) A summary of Mr. James William Munday’s qualifications and experience is provided in Appendix F of this report.
The investigation of Kroll involved a number of tasks including a detailed site inspection at Two Serendra and other relevant locations, examination of items removed from the incident scene to laboratories, in-person questioning of some witnesses and preparation of question plans for others, inspection of the LPG system operated by Bonifacio Gas Corporation ("Bonigas") and participation in formal briefings. After leaving the Philippines, further tasks included collation and interpretation of the physical and documentary evidence, engineering calculations, application of codes and standards, validation of methods and findings of the investigative teams and providing recommendations.  

Results of the Investigations

Explosions of this magnitude can be caused by a number of factors. The results of the investigation, however, eliminated the following potential causes:

1. The explosion was **not** caused by a bomb, whether improvised or manufactured, or any secondary device.  

   During the paneling operation, all nine (9) bomb sniffing dogs deployed by the K-9 Units at the blast site did not detect the presence of any explosive materials or residue. Reports of the Scene of the Crime Operative (SOCO), Southern Police District-Explosive Ordinance Disposal (SPD-EOD), National Capital Region Police Office (NCRPO)-EOD and the Taguig City Police Station (CPS)-EOD established that there were no bomb components (e.g. shrapnel, blasting caps, timers, etc.) found from the debris/scene of the explosion. Swabs taken by SOCO at the blast site also yielded negative results for the presence of any bomb residue.

   The BFP's post-fire investigation and NBI-EOD's post-blast investigation also established that no crater or bomb components were found on-site which thus ruled out the possibility that the explosion was caused by a bomb or explosive.

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5 The details of the investigation are contained in Part One of Kroll's Report, attached as Annex 2.
6 See IATF - Composite Team Report.
2. The explosion was not caused by any liquid flammable substances.\textsuperscript{10}

Laboratory examination conducted by the NBI-Forensic Chemistry Division and BFP-Arson Laboratory Section on the specimens taken from the blast site gave negative results for the presence of liquid flammable substances, i.e. gasoline, diesel, lacquer thinner, kerosene, acetone, paint benzene, ethyl alcohol, methyl alcohol, toluene, isopropyl alcohol, paint, varnish, butyl alcohol, biodiesel, acrylic thinner and other liquid organic compounds.

3. The explosion was not caused by methane gas.\textsuperscript{11}

The ocular inspection conducted by IATF - Composite Team revealed that the open-air sewer manhole is located outside the building, approximately forty-nine (49) meters away from Section B, Tower A. Given the foregoing, the explosion was least likely to have been caused by an accumulation of methane gas. In fact, per Technical Report dated 02 August 2013 of Dr. Idabel Bernabe-Pagulayan\textsuperscript{12}, Forensic Consultant, IATF - Composite Team-DILG, there was no presence of sewer gas or methane in Unit 501-B because there is no septic tank in the whole Section B, Tower A of Two Serendra.

In addition, the damage inside Unit 501-B is also consistent with an explosion caused by LPG, which is denser than air (Specific gravity air = 1.0, Propane = 1.52, Butane = 2.0, National Fire Protection Association [NFPA] Table 18.8), at the floor level, as opposed to an explosion caused by methane gas, which is lighter than air (Specific gravity air = 1.0, Sewage gas = .79, NFPA Table 18.8).

\textsuperscript{10} Id.
\textsuperscript{11} Id.
\textsuperscript{12} A summary of Dr. Idabel-Bernabe Pagulayan's qualifications is provided in Appendix G of this report.
4. The explosion was *not* caused by a faulty electrical system.\textsuperscript{13}

The result of the NBI Electrical Section laboratory examination eliminated electrical malfunction and/or short circuit of electricity as the cause of the explosion.

Given the foregoing, the blast was consistent with a gas explosion, particularly LPG. In eliminating all other elements, which were most likely to have caused the explosion, the only remaining source of combustible material of a sort sufficient to create an explosion of this magnitude is LPG gas. In Two Serendra, LPG is sourced from a centralized pipe-in LPG system.

The fact that it was LPG which caused the explosion was confirmed by the physical evidence of the leakage of the gas and the tests/analysis/calculation made by the investigators/experts establishing that an LPG explosion is sufficient to create the energy needed to detach the concrete slab in Unit 501-B and propel it to the moving Abenson delivery van located twenty-one (21) meters away.

\textsuperscript{13} See IATF - Composite Team Report.
III. WHAT HAPPENED

Background

The separate investigations conducted by the IATF - Composite Team and Kroll concluded that the explosion at Unit 501-B was directly caused by the ignition of escaped LPG. The escaped LPG, in turn, was determined to have come from a detached or improperly connected black braided flexible hose intended to supply gas to the cooking range.\(^\text{14}\)

Two Serendra uses a centralized pipe-in LPG system supplied by Bonigas. The system used by Bonigas involves the bulk supply of liquid LPG by Shell Philippines through its hauler, EMME-Subic Company, to Bonigas’ tank farm in Taguig City, where it undergoes conversion to vapor in a set of hot water vaporizers. From there, vapor is piped at regulated pressure through an underground system and distributed to the different buildings where a further pressure reduction takes place by secondary regulators maintained in the different buildings. The vapor then flows through the building’s internal pipe installations through further metering and thereafter distributed to the individual condominium units.

The LPG distribution system inside the building is protected by a manual shut-off valve at the base of the riser located at basement 1, and a “stand-alone gas leak detector” at the bottom of the riser located at the ground floor.

LPG is a mixture of two (2) main components, butane and propane. Based on the Supply Agreement between Bonigas and Serendra Inc. dated 15 February 2007, and the Sworn Statements of Mr. Ephraim Silang and Mr. Dennis Palomar, Technical Manager and General Manager of Bonigas, respectively, the LPG supplied by Bonigas to Serendra has a mixture of 30% propane and 70% butane.

LPG vapor is naturally odorless, colorless, non-toxic and potentially suffocating by oxygen exclusion, and denser than air. Because it is readily ignitable and therefore hazardous, Shell supplies

\(^{14}\) See Part One of Kroll’s Report and the IATF - Composite Team Report.
Bonigas with liquid LPG with an odorant additive, ethyl mercaptan, so as to alert users of the presence of a leak before it reaches dangerous concentrations.

Figure 3. LPG Distribution System
Unit 501-B

Unit 501-B is supplied with LPG vapor through the building's gas service pipe (stub-out). A flexible hose connects the stub-out pipe to the cooking range. Attached to the hose is a leak detector that is connected to an automatic shut-off valve. See illustration:

Figure 4. Illustration of the LPG Piping Layout at Unit 501-B
An actual installation looks something like this:

Figure 5. Gas Leak Detector, Shut-off Valve and Power Supply in Unit 801-B. Note the double socket outlet on the wall, only the range plugged in.
The Renovation and the Hose

During the renovation, it was established by physical evidence and sworn testimony that upon instructions of Manuel Gruta, the foreman and supervisor of RM Ladrido Construction Services (the contractor), Reynel Infante, worker of RM Ladrido, removed the LPG flexible hose attached to the range inlet, and transferred the range to the living room in order to shorten the kitchen countertop by nine (9) inches.\textsuperscript{15} This modification, however, was implemented by the contractor despite the fact that it was not included in the Scope of Works disclosed to and approved by Two Serendra.\textsuperscript{16}

1. Unit 501-B is owned by Mrs. Marianne Ochoa Cayton who currently lives in Anaheim, CA. Mrs. Cayton engaged the services of C+G Design Studio to renovate Unit 501-B and contracted RM Ladrido Construction Services to do the renovation and reconfiguration of the unit’s layout.

2. The design required the construction of partition walls and doorways to form two bedrooms, relocation of washing machine to the east end of the kitchen, demolition of the concrete walls between the living room and the west end of the bathroom, repositioning of the furnishings to suit the new room layout, transfer of the circuit breaker behind the bathroom wall, adding four (4) convenience outlets, painting and other decorative works.

3. The renovation plan was approved by Engineer Sherhan Mohammad of Two Serendra. The renovation started on 01 April 2013 and was completed on 28 May 2013.

4. During one of the site visits of Charice Benetua, the Interior Designer of C+G Design Studio around the first week of May 2013, Manuel Gruta, the foreman and supervisor of RM Ladrido, suggested that the kitchen cabinet be adjusted although this was not included in the approved Scope of

\textsuperscript{15} Sworn Statements dated 25 July 2013 of, Clotildo Cuizon, Jr., Manuel Gruta and Joselito Zamora, workers of RM Ladrido, Annexes EEE, FFF and NNN of the IATF - Composite Team Report.

Works. Charice Benetua approved the suggestion provided that (a) the gas line will not be affected; and (b) Mr. Gruta secure the approval of Serendra.

5. On 07 May 2013, Manuel Gruta instructed Reynel Infante to remove the LPG hose connected to the cooking range. Upon removal, Reynel Infante smelled the hose to check for escaping air. After learning that there was none, Mr. Infante transferred the range to the living room to allow the carpenters to move around.

6. Joselito Zamora, a carpenter of RM Ladrido, disclosed that he unplugged the gas leak detector when the kitchen counter top was being cut to accommodate the range in the northeast corner of the kitchen following modifications made to the north end of the kitchen during the renovation. He further disclosed that he thought that the detector was a buzzer, and he did not notice a light when he plugged it back in the outlet.

7. On 17 May 2013, Manuel Gruta instructed Clotildo Cuizon, Jr. and Joselito Zamora to return the range to the kitchen. Clotildo Cuizon disclosed that he asked Joselito Zamora to attach the hose to the “LPG” since Zamora had a screwdriver. Zamora thereafter attached a braided flexible hose at the back of the range to a connector.

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8. Following the renovation, Mrs. Marianne Cayton visited Unit 501-B on 23 May 2013 and gave a punch list for retouching the painting and cleaning the unit. Subsequently, Clotildo Cuizon, Jr. and Dennis Dumaguising returned to clean the unit and retouch the splatter of paint.

9. A comparison of the unit layout before and after renovation is illustrated below:

Figure 6. Pre Renovation Layout of Unit 501-B

Figure 7. Post Renovation Layout of Unit 501-B.
10. The effect of the renovation on the location of the gas range is shown below:

![Figure 8](image1.jpg)  
![Figure 9](image2.jpg)

Figure 8. Typical size of a kitchen countertop measuring 67 inches in Unit 802-B.  
Figure 9. Kitchen countertop measuring 58 inches in Unit 501-B after scene reconstruction.

11. On 30 May 2013, Clotiildo Cuizon, Jr. accompanied by Angelito Inlayo gave the keys of Unit 501-B to Mrs. Alicia Ochoa-Mendez, sister of Mrs. Cayton.

12. A request by the unit owner and the contractor for final inspection of Unit 501-B was refused by Engineer Sherhan Mohammad of Two Serendra because no as-built plans were submitted by RM Ladrido or C+G Design.\textsuperscript{24}

\textsuperscript{24} Sworn Statement of Sherhan Mohammad dated 04 July 2013, Annex LLL of the IATF - Composite Team Report.
The Hose

Physical evidence also showed that the flexible hose which was detached during the renovation of the Unit by RM Ladrido Construction Services, was either still detached from or loosely connected to the range inlet. Kroll also considered the possibility that there may have been surge of gas when the gas meter valve was opened, causing a poorly clamped hose to slide off the range inlet. Upon examination, the screw clamp of the black braided flexible hose located near the connector to the range inlet was loose, contrary to Joselito Zamora’s claim that he reattached the hose to the range using his screwdriver.

The paint drip position on the flexible hose, which was perpendicular to the pipe axis, also indicated that it had been deposited while the hose was horizontal, or lying on the floor.\(^{25}\) If attached to the range, the flow pattern of the paint would have been close to vertical.

Per SOCO’s Forensic Correlation Report dated 05 June 2013:

“The flow pattern of a dried paint drip about 5.2 cm from the tip of Point B shows that the paint dripped on the hose while the hose is lying on its side and not while positioned vertically. The most probable way that this could happen is when the hose is lying on the floor. This means that for quite some time, the hose is not attached to the cooking range nozzle.”

![Figure 10, Flow pattern of the paint drip approximately 5.2 cm from Point B (open end of hose supposed to be connected to the range inlet).](image)

\(^{25}\) See Part One of Kroll’s Report and the IATF - Composite Team Report.
Moreover, the paint samples taken inside Unit 501-B coincide with the paint drip on the flexible hose, per DOST Advance Device and Materials Testing Laboratory’s Report of Test dated 29 July 2013.

Figure 11. Open end of hose supposed to be connected to the stub-out pipe, with tight clamp.

Figure 12. Paint drip approximately 5.2 cm from Point B (open end of hose supposed to be connected to the range inlet). Inset photo shows a loose clamp approximately 24 cm from Point B.

Based on the foregoing, both IATF - Composite Team and Kroll concluded that the source of the fuel was an open flexible hose in the kitchen disconnected during renovation but not properly reconnected to the gas range inlet after renovation.
The Gas Leak

On 31 May 2013, the escape of the LPG vapor remained undetected for 13.25 hours, or specifically from 7:00 a.m., when the valve was opened by Mr. Ariel Mendez, husband of Mrs. Alicia Ochoa-Mendez, until 8:15 p.m. when, after the explosion, the main supply was manually shut off by the Utilities Management Group (UMG)\(^{26}\) and Jardine Energy Control (JEC)\(^{27}\) of Two Serendra. The leak was not detected due to several factors:

1. The gas detector of Unit 501-B failed to detect the leak because it was either unplugged or the branch circuit for convenience outlets was turned off rendering the detector inoperable even if plugged in the wall outlet. Note that per reports, the building had no power for a period of 9 hours.\(^{28}\)

Moreover, the automatic shut-off valve to which the detector was electrically connected is a “normal-on” type or “fail-open” design. This means that the pipe-way is normally open even during power failure. It closes electronically only when it receives a signal from the detector. This differs from a “normal-off” or “fail-closed” valve, which means that the pipe-way is normally closed, even during power failure. The spring or gravity closer is electrically opened to allow the flow of gas. When it receives a signal from the detector that it does not detect any gas, the valve shuts automatically if the sensor detects gas and interrupts the supply. The “normal-off” valve will

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\(^{26}\) Serendra Inc. owns Two Serendra and its electricity and LPG distribution facilities. Serendra Condominium Corporation manages the common areas, while Direct Power Services Inc. manages the electricity and LPG distribution system facilities of Two Serendra including requests for activation/deactivation of electricity and LPG, complaints, meter reading for billing, among others. (Sworn Statement of Dave Andrew Opiso, Associate Director of Direct Power Services Inc., dated 05 July 2013, Annex NNNN of the IATF - Composite Team Report)

Direct Power has two (2) sub-units: Retail Electricity Services, and UMG. UMG provides customer service and handles the billing for the LPG consumption. JEC, on the other hand, conducts the maintenance of the LPG system. (Per Sworn Statement of Mary Joy Cruzado, Utilities Officer of Direct Power, dated 10 July 2013, Annex OOOO of the IATF - Composite Team Report)

\(^{27}\) JEC is a multi-national company contracted by Serendra Inc. to render operation and maintenance services for the common areas and the electrical and LPG systems of Two Serendra. Only the personnel from JEC are authorized to open and shut-off the gas supply of each unit. JEC assists Mechatrends Contractors Corporation in the safety inspection of the LPG distribution system of Two Serendra. (Sworn Statement of Evelyn Leviste, Operation and Maintenance Assistant Manager of JEC, dated 04 July 2013, Annex QQQQ of the IATF - Composite Team Report)

\(^{28}\) From 8 a.m. to 5 p.m.
also close in the event of power loss, whereas the type fitted in Unit 501-B would stay open.

2. The “stand-alone gas leak detector” at the bottom of the riser located at the ground floor (Unit 101-B, Section B, Tower A) chase did not activate because the escape gas vapor was confined inside Unit 501-B, and did not enter the chase and reach the ground floor sensor.

However, Kroll reported that because LPG vapor is denser than air and there is witness information that the meter cupboard door was open, some of the vapor, which escaped into the corridor, could have descended the riser duct to ground floor level. Kroll also reported that it is possible that the vapor was sufficiently diluted at ground floor level and thus, did not activate the sensor.29

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29 Per NBI Electrical Report dated 21 June 2013, the leak detector at the bottom of the riser did not operate since it was switched off.
**Ethyl Mercaptan, the Odorant**

The additive odorant, ethyl mercaptan, was not detected or reported by anyone entering or going to the unit or passing through the common areas during the day. The DOH Final Technical Report dated 02 August 2013 revealed that “the result of the rapid assessment where the calculated PID reading for ethyl mercaptan of $1.1 \times 10^{-8}$ ($0.000000011$) was below the odor threshold of 0.0000087 ppm and the LOA (Level of Distinct Odor Awareness) of 0.00014.” (Italics supplied)

Olfactory testing was also carried out by Kroll at Bonifacio Global City on 16 June 2013 when it noticed that the odor of vapor emitted directly from the underground liquid storage tanks was very strong. However, opening a valve immediately downstream of the vaporizers resulted in a weak odor, which was undetectable more than a few centimeters away.

![Figure 13. Bonigas vaporizer plant, Taguig City](image)

This supported the findings of the “sniff test” conducted by the BFP at the Brasilia restaurant which indicates that the ethyl mercaptan odorizer is lost at the vaporization stage before the vapor is supplied to the Bonifacio Global City centralized pipe-in LPG system.
The Volume of LPG and Flammability Range

The total volume of LPG which accumulated inside Unit 501-B was 35.221 \( m^3 \), derived by subtracting the initial meter reading (as of 28 May 2013) of 4.576 \( m^3 \) prior to opening the gas valve, from the final meter reading of 39.797 \( m^3 \) after the explosion. Per Kroll’s calculation, similar to the calculation of IATF - Composite Team, the volume of gas that escaped at the time of explosion (prior to 8:00 p.m.) was 34.56 \( m^3 \).

Like all fuel gases and vapors, butane and propane can only be ignited when mixed with air in the correct proportions. The explosion occurred when a mixture of LPG vapor and air within the lower explosion limit (LEL) and the upper explosion limit (UEL) was ignited.

<table>
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<th>Flammability range</th>
<th>IATF - Composite Team</th>
<th>Kroll</th>
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<tbody>
<tr>
<td>Butane</td>
<td>LEL: 1.9 – UEL: 8.5%</td>
<td>LEL: 1.9 – UEL: 8.5%</td>
</tr>
<tr>
<td>Propane</td>
<td>LEL: 2.15 – UEL: 9.6%</td>
<td>LEL: 2.1 – UEL: 10.1%</td>
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<tr>
<td>LPG vapor as a single gas</td>
<td>LEL: 2 – UEL 10%(^30)</td>
<td>LEL: 2 – UEL: 10%</td>
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Given the Height x Width x Length Dimensions of Unit 501-B, it had a static volume of 131.67 \( m^3 \) (per IATF - Composite Team) and 132.8 \( m^3 \) (per Kroll).

The measured 34.56 \( m^3 \) (per Kroll) escaped LPG gas would put it at 26.02% of the unit volume, while using IATF - Composite Team’s calculations, the measured 35.22 \( m^3 \) escaped LPG gas would amount to 26.74% of the unit volume.

Kroll explains that the vapor concentration in Unit 501-B prior to the explosion was 78%, which is far too high to ignite. Given the foregoing, much of the escaping gas must have left the unit via doors and windows prior to the explosion. (Note that there was no power in Serendra for approximately 9 hours.)

Taking the UEL of 10%, assuming a perfect mixing of gas and air, the maximum gas volume in the effective unit volume would have been 4.43 \( m^3 \). Thus, 30.13 \( m^3 \) (34.56 \( m^3 \) – 4.43 \( m^3 \)) of vapor was lost outside the unit during the escape, which would have leaked to the atmosphere.

via the windows, door, corridor and drifted through the building. However, in practice, there would not have been a perfect mixing. As long as the concentration near the ignition source was within the explosion limits, the turbulence resulting from ignition would rapidly disperse all the vapor within the whole unit volume. To achieve a mean concentration of 4.5% (stoichiometric ratio) in the whole unit would require 5.4 m³, leaving 29.1 m³ (34.56 m³ – 5.4 m³) to be dispersed outside the unit. Thus, from both calculations, approximately 30 m³ of LPG vapor escaped from Unit 501-B during the duration of the leak.  

IATF - Composite Team, on the other hand, in explaining the explosion, used an alternative calculation method based on separate assessments for the butane and propane flammability limits and concentrations. Using a figure of 70% butane, the mean concentration assuming a perfect mixing of gas and air in the whole unit volume is 18.61%. A 30% propane LPG composition yields a mean concentration of 7.97%, which is within the propane explosive limits of 2.15 – 9.6%.  

Kroll disagreed with the IATF - Composite Team methodology because “this concentration is at the high end of the flammability range and would therefore be expected to cause less overpressure but more burning. However, the very rich butane component, approximately 18%, would not initially ignite due to excess fuel. Once additional ventilation was available, due to structural failure, the excess vapour would continue to burn until consumed over a period of several seconds or longer. This would be expected to cause much more severe heat and flame damage than that observed within Unit 501B.”  

“The IATF - Composite Team reasoning on this method is therefore questionable and it is considered that the alternative method of considering the vapour mixture as a single effective source is more valid.”  

In either case, both Kroll and IATF – Composite Team confirm that it was LPG that exploded and the concentration and mixture of the air falls within the accepted upper and lower limits of the LPG, whether taken as a whole or computed based on its components, Butane and Propane.

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31 The details of the computation are contained in Part One of Kroll’s Report.  
32 The details of the computation are provided in the IATF - Composite Team Report.  
33 Part One of Kroll’s Report, page 43.  
34 Id.
Energy Force Released

The explosion incident caused damage to Unit 501-B and other properties, including a passing Abenson delivery van, which was twenty-one (21) meters away from the blast site. Thus, it is therefore necessary to determine if the amount of energy released by the LPG explosion would produce sufficient force to cause the damage observed.

<table>
<thead>
<tr>
<th></th>
<th>IATF - Composite Team(^ {35} )</th>
<th>Kroll(^ {36} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Est. amount energy released by the explosion</td>
<td>1,290.5 MJ</td>
<td>606.5 MJ</td>
</tr>
<tr>
<td>Est. energy needed to propel the wall</td>
<td>1.377 MJ</td>
<td>1.4 MJ</td>
</tr>
</tbody>
</table>

Based on the foregoing calculations, the estimated amount of energy released by the LPG explosion was sufficient to propel the wall that hit the Abenson delivery van.

\(^ {35} \) The details of the computation are provided in the IATF - Composite Team Report.

\(^ {36} \) The details of the computation are provided in Part One of Kroll's Report.
Light Switch as Ignition Source

Both IATF - Composite Team and Kroll investigations concluded that the source of ignition was the operation of the light switch beside the door as Mr. Angelito San Juan was about to leave the unit.

The explosion of a material produces a large quantity of gases. These gases expand at a high speed and move outward from the point of origin. The gases and displaced air moved by the gases produce a pressure front that is primarily responsible for the damage and injuries associated with such explosions. (NFPA 921, 2001 Edition)

The blast pressure front occurs in two (2) distinct phases: the positive pressure phase and the negative pressure phase, based on the direction of the forces in relation to the point of origin of the explosion. The positive phase is that portion of the blast pressure front in which the expanding gases are moving away from the point of origin. Thus, a lower pressure condition is created at the epicenter of the origin. When the positive pressure dissipates, air rushes back to the area of origin to equilibrate the low air pressure condition, creating the negative pressure, which causes secondary damage and move items of physical evidence toward the point of origin. (NFPA 921, 2001 Edition)

An examination of the damage caused by the explosion at Unit 501-B and the surrounding structures/areas determines the source of the ignition (point of origin), which is the light switch located beside the front door at the south wall of the unit. The injuries sustained by Mr. Angelito San Juan also indicate that he was at the epicenter of the explosion. This is supported by the whole-of-body burn distribution, with more severe patches probably associated with burning clothing adhesion to the skin. Moreover, based on the Sworn Statement of Mrs. Herminia Ochoa dated 11 July 2013, Mr. Angelito San Juan was at the door when the explosion occurred.
Summary - Sequence of Events

Based on the foregoing, the sequence of events leading to the explosion is summarized as follows:

1. On 31 May 2013, at around 5:21 a.m., Mr. Angelito San Juan arrived in the Philippines. Mrs. Alicia Ochoa-Mendez, together with her husband Ariel Mendez, daughter Arlean Mendez and sister Herminia Ochoa fetched Mr. San Juan at the airport. Prior arrangements had already been made with Mrs. Cayton for Mr. San Juan to stay at Unit 501-B for nine (9) days from 31 May 2013.

2. At around 6:30 a.m., Mr. San Juan, Herminia Ochoa, Alicia, Ariel and Arlean Mendez went to Unit 501-B at Two Serendra. Ariel Mendez opened the LPG valve inside the unlocked meter cabinet located outside the unit, which he claimed was the standard operating procedure. After 30-40 minutes, everyone left the unit.

3. At around 1 p.m., Mr. San Juan returned to the unit accompanied by a security guard who helped him carry his groceries from the basement car park.

4. During the day, the annual electrical maintenance was in progress, which limited the power supply to each of the units. The tenants can, however, use an electric fan and obtain ventilation through opening of windows. Mr. San Juan complained to Herminia Ochoa and Alicia Ochoa-Mendez that there was no power and he was feeling suffocated.

5. At around 7:15 p.m., Mrs. Herminia Ochoa arrived at the building’s lobby to collect Mr. San Juan for dinner, having previously sent a text message. When he failed to appear, Nebster Falcasantos, a security guard of Two Serendra, went to Unit 501-B but was unable to get a reply. While waiting, Mrs.

Ochoa tried to contact Mr. San Juan by phone several times, but he did not answer.

6. At around 7:50 p.m., Mrs. Herminia Ochoa accompanied by Security Officer Ramil Arsola and Security Guard Falcasantos proceeded to Unit 501-B. After knocking on the door several times and ringing the doorbell successively, Mr. San Juan slightly opened the door and told them he fell asleep. Mrs. Ochoa entered the Unit and said she recognized the smell of fresh paint. She then reminded Mr. San Juan that their dinner reservation was at 7:00 p.m. Mr. San Juan said he would get dressed and meet Mrs. Ochoa at her car. Mrs. Ochoa then left the Unit, went down to her car and waited for Mr. San Juan.

7. Security Officer Arsola stated that there was no light inside the unit, while Security Guard Falcasantos said it was dim. Falcasantos also recalled smelling fresh paint.

8. At approximately 7:59 p.m., the explosion occurred. Thereafter, Mrs. Herminia Ochoa saw a bloody Mr. San Juan at the lobby. Much of his shirt was burnt off and only his collar remained. Mr. San Juan then told her: “I turned on the door knob I heard an explosion I was thrown on the floor and felt electrocuted”.

9. Mr. San Juan’s injuries indicated that he sustained extensive burns all over his body. Dr. Christian Aro described superficial partial thickness burns to Mr. San Juan’s torso, back, legs, face and hands. He had deep partial thickness burns to his right lower back, both calves, left hand and full thickness burns to the right ankle.

10. After the blast, the UMG, in-charge of the electricity and LPG distribution facilities of Two Serendra, shut-off the main valve.

40 Sworn Statement of Nebster Falcasantos dated 06 June 2013, Annex QQQ of the IATF - Composite Team Report.
11. Several residents of Two Serendra were evacuated from their units.
## IV. POSSIBLE RESPONSIBILITY/LIABILITY OF PARTIES FOR THE GAS EXPLOSION AND/OR ITS CONSEQUENCES

<table>
<thead>
<tr>
<th>PARTIES</th>
<th>IATF - Composite Team - Composite team Investigation(^{42})</th>
<th>KROLL Investigation(^{43})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. RM Ladrido Construction Services</td>
<td></td>
<td>Lack of adequate supervision and checking of renovation activities.</td>
</tr>
<tr>
<td>2. Manuel Gruta, Supervisor and Foreman of RM Ladrido Construction Services</td>
<td>Failure to exercise due diligence in the supervision of the daily activities of the workers, specifically when he allowed Reynel Infante to disconnect the LPG hose without ensuring first that all precautionary measures have been observed by Infante. Despite the fact that the workers work 9 hours a day (from 8am to 5pm), he admitted that he visited the site only 3 times a week and stayed only for 2 to 3 hours. He failed to ensure that prior to the turnover of the Unit, all the safety features inside the Unit have been activated or are in place. Moreover, he failed to ensure that the</td>
<td></td>
</tr>
</tbody>
</table>

\(^{42}\) See IATF – Composite Team Report.

\(^{43}\) Part Two of Kroll’s Report, attached as Annex 2, specified several contributory and associated factors that caused the explosion.
<table>
<thead>
<tr>
<th></th>
<th>Renovation had a building permit from Taguig Building Officials and Fire Safety Evaluation Clearance from the Taguig Fire Station prior to its commencement as none were secured.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Reynel Infante, plumber of RM Ladrado</td>
<td>Failure to observe precautionary measure when he intentionally removed the flexible hose from the range inlet during the renovation and left it disconnected until the opening of the LPG on the morning of 31 May 2013, causing the LPG gas to accumulate inside the unit within its explosive limit, which triggered the explosion.</td>
</tr>
<tr>
<td>4. Clotildo Cuizon, Jr., painter and timekeeper of RM Ladrado</td>
<td>Failure to reconnect the LPG flexible hose to the range inlet despite knowledge of its detachment and the instructions of Manuel Gruta for him to reconnect it.</td>
</tr>
</tbody>
</table>
|   | Failure to observe due diligence in checking the LPG hose connection before he opened the LPG valve on 31 May 2013. His act of turning on the LPG valve in the LPG cabinet violated the established rule in Serendra that only the maintenance personnel from JEC are authorized to open the LPG meter cabinet and that any activation or deactivation of the gas supply from the gas valve in the LPG meter cabinet requires the authorization of the JEC Supervisor. | Reinstatement of gas supply to the unit by an unauthorized person contributed to the explosion.  
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44 "The gas supply to Unit 501B was reinstated by a relative of the owner who was not authorized to do so. However there is evidence to suggest that the meter cabinet doors were habitually left unlocked, possibly for convenience when reading the meters. If this door had been locked, it would have been more difficult for the supply to have been reinstated without authority." Id.

45 "Mr San Juan had been given permission to occupy Unit 501B without an engineer’s inspection following the renovation. An engineer’s inspection based on accurate as-built plan should have identified the disconnected hose before reinstatement of the gas supply", Part Two of Kroll’s Report, page 4. |   |   |   |
| 5. Ariel Mendez |   |   |   |
| 6. Mariane O. Cayton, owner of Unit 501-B | Failure to obtain the corresponding Building Permit and Fire Safety Evaluation Clearance for the renovation of the unit. |   |
| 7. Two Serendra, Inc. | Occupancy resumption after renovation without an engineer’s inspection and certification, and lack |   |
of security of Unit 501-B meter cabinet and failure to tag off the closed valve contributed to the explosion.

International standards and best practices involve the use of safety features not currently present in Bonifacio Global City and Two Serendra installations. These include: fixed positioning and hard wiring of all sensors to avoid user intervention; use of fail-safe (fail-closed) sensor-valve systems; use of under-pressure shut-off valves to detect and prevent large escapes in the consumer pipes and hoses; use of convenience outlets for moveable appliances; involvement of a suitably qualified chemist or chemical engineer in the supply chain and operation; odorizer concentration monitoring in pipelines; prevention of unauthorized person access to equipment.

8. Makati Development Corporation

Building construction factors which increased the extent and severity of the overpressure effects.\(^{47}\)

\(^{46}\) Id.

\(^{47}\) Id.
| 9. Bonifacio Gas Corporation | Parts of the building construction did not meet the requirements set forth in the Philippine National Fire Code and its reference documents. Specifically, a number of vertical ducts and chases were not fire-stopped between levels.  

| | Weakness of the gas odorant ethyl mercaptan in the piped LPG vapor supply, which could have alerted the occupant/tenants to a leak, most probably resulting from losses at the vaporization stage.  

| | International standards and best practices require the involvement of a suitably qualified chemist or chemical engineer in the supply chain and  

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47 "External and internal wall fixings to the horizontal slabs were insufficient to resist the overpressure and this resulted directly in the projection of the east wall concrete slab onto the road way, causing three deaths. It is fortunate that neighbouring units were unoccupied at the time of the incident; otherwise there would have been more deaths and serious injuries from the structural response," Part Two of Kroll's Report, page 5.

48 Although no fire followed the explosion in this case, that result was fortuitous. Had a fire developed, it is likely that such would have spread from the 5th floor to other levels. The same ducts and chases provided a pathway for pressure wave travel between levels and into the roof.

49 "Commercial grade LPG vapour should emit a strong and unpleasant odour which is provided by a chemical known as methyl mercaptan added to it. No one in or visiting the building was aware of any such odour prior to the explosion, despite a high flow rate of LPG vapour within and from the unit. It was apparent that much of the ethyl mercaptan odoriser was lost at the vaporization stage before the vapour was supplied to the Bonifacio Global City piped gas system. Thus the vapour escaping at Unit 501-B and at other locations tested did not have the usual strong and unpleasant odour alerting occupant to a leak."

Id.
V. RECOMMENDATIONS

On the basis of the evidence gathered and the results of the investigation of the IATF - Composite Team and Kroll, the culpability of each of the parties and the extent of their liabilities will be determined by the DOJ, which shall recommend the filing of the appropriate criminal and/or civil cases in the proper courts. Recommendations on the strict enforcement of existing laws, as well as the amendment/modification of certain provisions thereof, including the adoption of international standards and best practices to avoid similar incidents in the future, are detailed below:

1. For DOJ to make the necessary evaluation on the liabilities of the persons implicated in the explosion, pursuant to Section 4.2 of Presidential Memorandum Order No. 371.\footnote{50}

2. For DILG, in coordination with the DOE, DTI, BPS, BFP and other concerned agencies/stakeholders to adopt or formulate the following standards/guidelines: Standard for Gas Leak Detector; Maintenance Guidelines for LPG Detector; and Standard for Vaporizer Machine and LPG Vapour State Distribution System.\footnote{51}

3. For DILG to review the existing MOA or execute a new MOA between DILG, DOE and DPWH regarding the conduct of joint inspection of LPG farm/facility, Serendra buildings and other buildings/establishments within Bonifacio Global City that have centralized LPG vapor state distribution systems, and the piping system layout of Bonifacio Global City, in order to avoid similar incidents in the future.\footnote{52}

4. For BFP and building officials to conduct a comprehensive review of existing buildings using centralized pipe-in LPG system and any alterations to the piping system layout.\footnote{53}

5. International standards and best practices involving the use of some safety features not currently present in Bonifacio Global

\footnote{50}{See IATF – Composite Team Report.\footnote{51}{Id.\footnote{52}{Id.\footnote{53}{Id.}}}}
City and Two Serendra Installations should be adopted. These include: fixed positioning and hard wiring of all sensors to avoid user intervention; use of fail-safe (fail-closed) sensor-valve systems; use of under-pressure shut-off valves to detect and prevent large escapes in the consumer pipes and hoses; use of convenience outlets for moveable appliances; involvement of suitably qualified chemist or chemical engineer in the supply chain design and operation; odorizer concentration monitoring in pipelines; prevention of unauthorized person access to equipment.\footnote{54}

6. Consideration should be given to developing a regulatory framework based on international standards and best practices, to govern the design and use of LPG vapor distribution networks in the Philippines.\footnote{55}

7. Noting that the Two Serendra Condominium documents “House Rules and Regulations” and “Design Construction Guidelines” were poorly drafted and ambiguous in content and application, consideration should be given to a national model framework for such documents, adaptable to developers’ and residents’ specific circumstances.\footnote{56}

8. Develop a model framework for condominium occupancy rules, which can be applied to specific circumstances. Reoccupation of units should not be permitted after renovation without an engineer’s inspection and issuance of a Certificate of Occupancy; and\footnote{57}

9. Develop a national regulatory framework for the design, installation and use of piped LPG vapor and other fuel gas systems based on international standards and best practices.\footnote{58}

END.

\footnote{54}{See Part Three of Kroll’s Report, attached as Annex 2.}
\footnote{55}{Id.}
\footnote{56}{Id.}
\footnote{57}{Id.}
\footnote{58}{Id.}