



Method Statement

# Air Raising

BU/PR 35000 M3  
Kharg Island  
Kharg Petrochemical Company

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## 1. Scope

This document covers the basic plan of roof air-raising for Bu/Pr tank in Kharg Island.

## 2. General View

The steel roof structure and the suspended deck are assembled on the bottom of the tank, and are raised up by supplying the air from blowers through a temporary air duct.

The following figure shows the outline of the roof air-raising system.

Diameter of Tank:	42 m
Roof radius:	35.7 m
Weight of roof:	Approx. 240 ton
Height of outer tank:	31.5 m
Height to be raised:	30 m
Pressure for raising:	1870 Pa.
Air blower:	500m <sup>3</sup> /min, 600mm H <sub>2</sub> O, 3 sets (2 in operation, 1 standby)
Raising speed:	200mm – 400 mm
Estimated time:	Approx. 150 min
Roof leveling system:	Leveling wire system (14-16mm wire dia.)
Air Sealing System:	Vinyl seal reinforced with wire mesh

## 3. Data for Air-raising

- 1) Weights of Raised Materials (calculated based on current drawings)

Total  $W=240$  ton

- 2) Raising Pressure  $P$

$$P = W / \pi \cdot D^2 / 4 \times 1.1 = 1950 \text{ Pa } (\approx 195 \text{ mm Aq}).$$

(1.10 : 10% allowance against the friction between sealing material and metal surface)

(D: Diameter of the Tank 42 m)

- 3) Raising Speed  $V$

200mm-400mm/min (based on the capacity of blowers)

- 4) Raising Time  $H$

Height to be raised is approx. 30 m.

Then, the raising time becomes : Approx. 150 min

- 5) Required Quantity of Air  $Q$

$$Q = \pi \cdot D^2 / 4 \cdot V \cdot Q'$$

D : Inner Diameter of the Tank 42 m

V : Raising Speed Max 0.4m/min

Q' : Percent of Leakage Volume from the Sealed Portion:  
30%( Based on Experiences)

$$Q=720 \text{ m}^3 / \text{min}$$

Specifications of the Blowers:

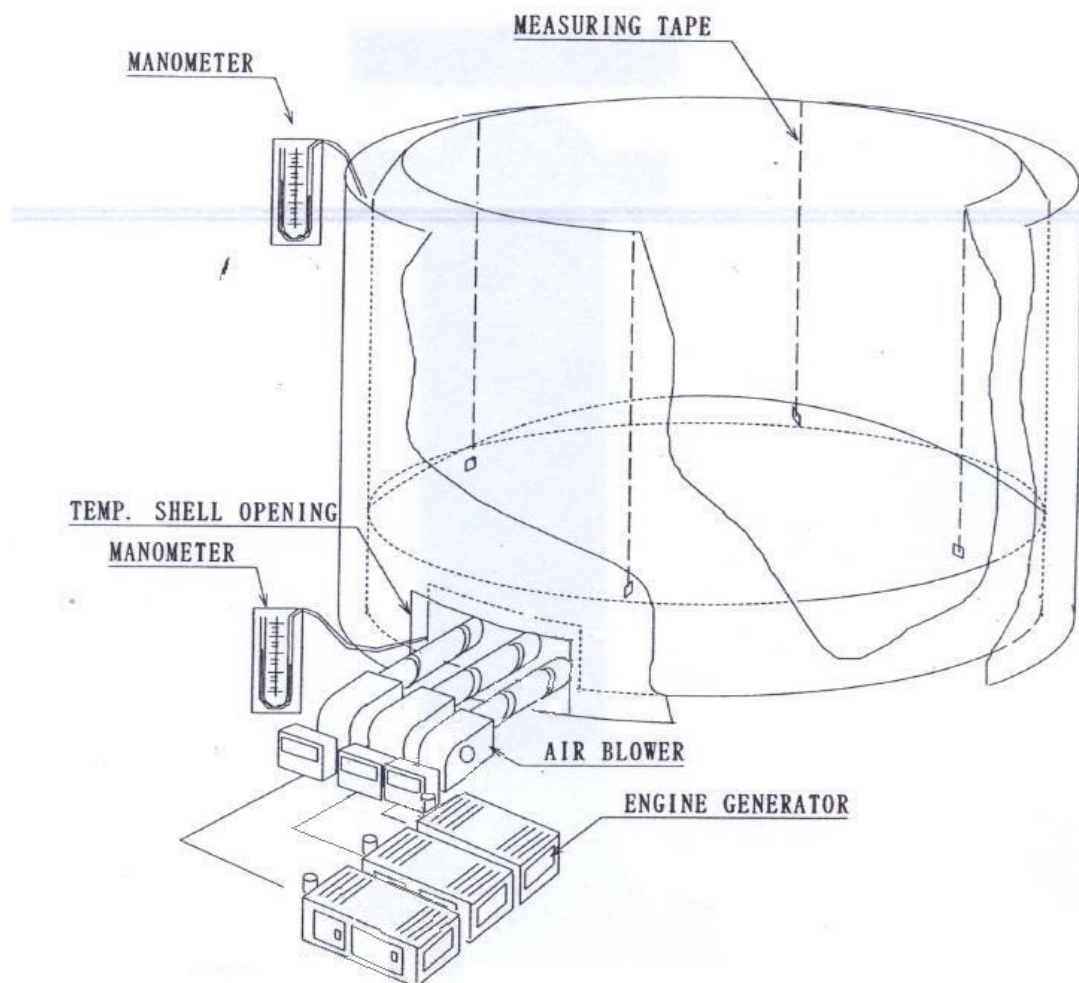
Pressure: 6000mmAq, Capacity: 600m<sup>3</sup> /min.

Number of Blowers: 3 sets (2 for operation, 1 for stand-by)

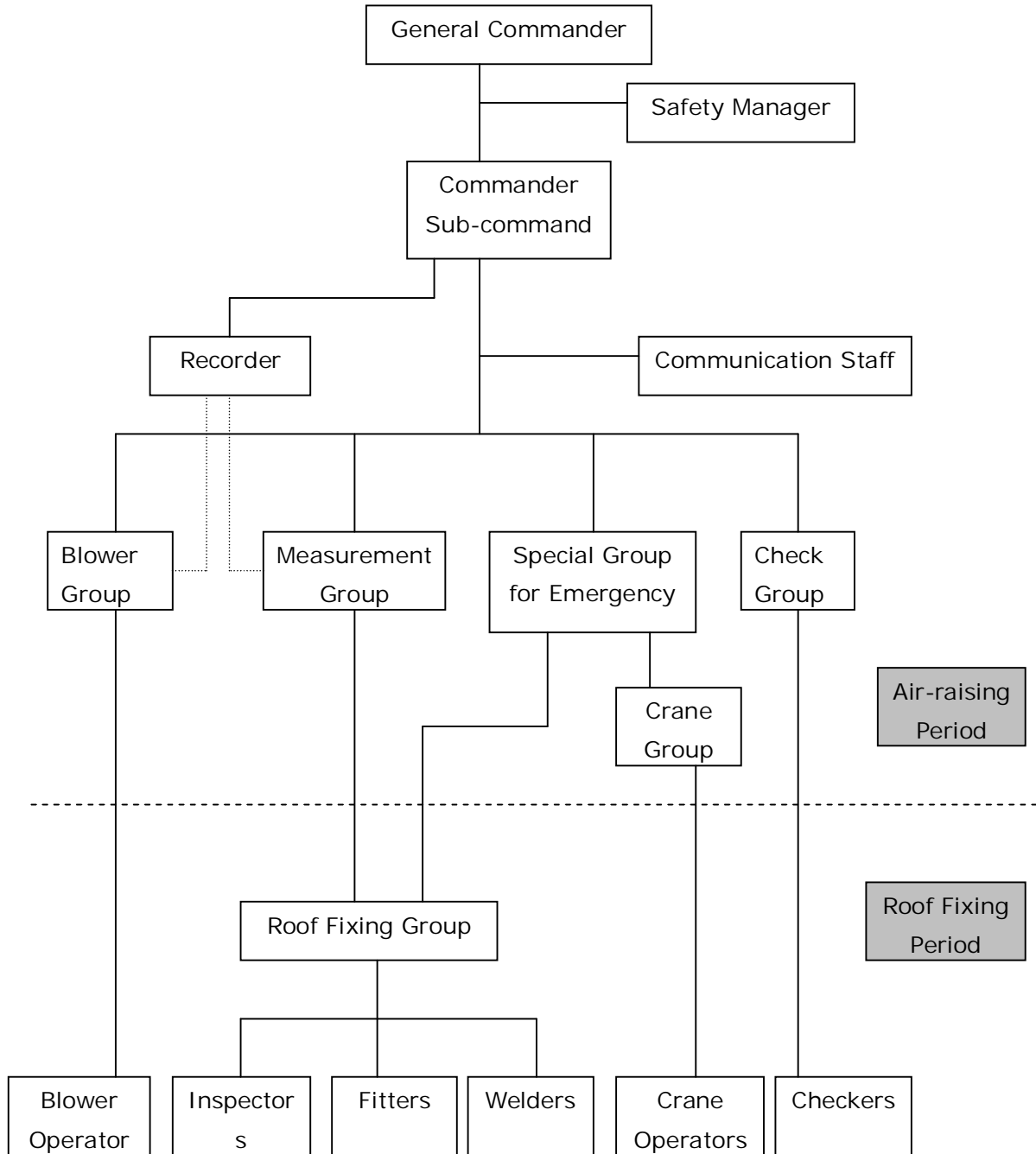
Then,  $600 \times 2 = 1,200 \text{ m}^3 / \text{min} > 720 \text{ m}^3 / \text{min}$

#### 6) Mandatory Items to be Monitored

The roof inclination should be always carefully monitored during the air-raising period. If the value becomes close to the control one ( $D/500$ ), the raising process should be once stopped and the tension of balance wires should be adjusted within their control value for reducing the inclination, and then the roof is air-raised again slowly.



#### 4. Organization Chart



#### 5. Preparation for Air-raising

##### 5.1 Temporary Closing of "Roof Opening for Construction"

The "Roof Opening for Construction" should be temporarily closed by steel plates. It should be re-opened after the air-raising works are completed.

## 5.2 Arrangement of Balance Wires

The balance wires should be stretched from the top of the tank, via the outer surface of the roof and via inside across the tank center, and fix to bottom Plate.

- (1) Set up anchors in the bottom Plate (The setting up works should be conducted by expert supervisor).
- (2) Fix the sheaves (28 pcs.) to periphery of the roof.
- (3) Set up supporting arms on the top of the Tank.
- (4) Each wire should be pulled toward the center of the bottom concrete, and be fixed to the embedded anchor by using clips.
- (5) Each wire should be stretched by each turn buckle until the tension reaches to 1000 kgf.

The tension load shall be checked by using resonant frequency method, according to the following formula:

$$F = (1/2XL) \times \sqrt{(S \times G/D)} = \text{min 15 Times per 10 second}$$

Where

- F = frequency of vibration (per second)
- L = free length of leveling wire (32m)
- S = pre-tension load (1000 Kgf)
- G = gravity acceleration (9.8 m/sec<sup>2</sup>)
- D = wire mass (1.1 kg/m)

$$\Rightarrow F = 1.47 \Rightarrow 15 \text{ times per 10 second}$$

- Important Note: the wires between top Bracket and guide Rollers (sheaves) shall be install vertically (tolerance $\pm$ 5)

## 5.3 Scaffolding for welding roof to compression rings (gusset plate):

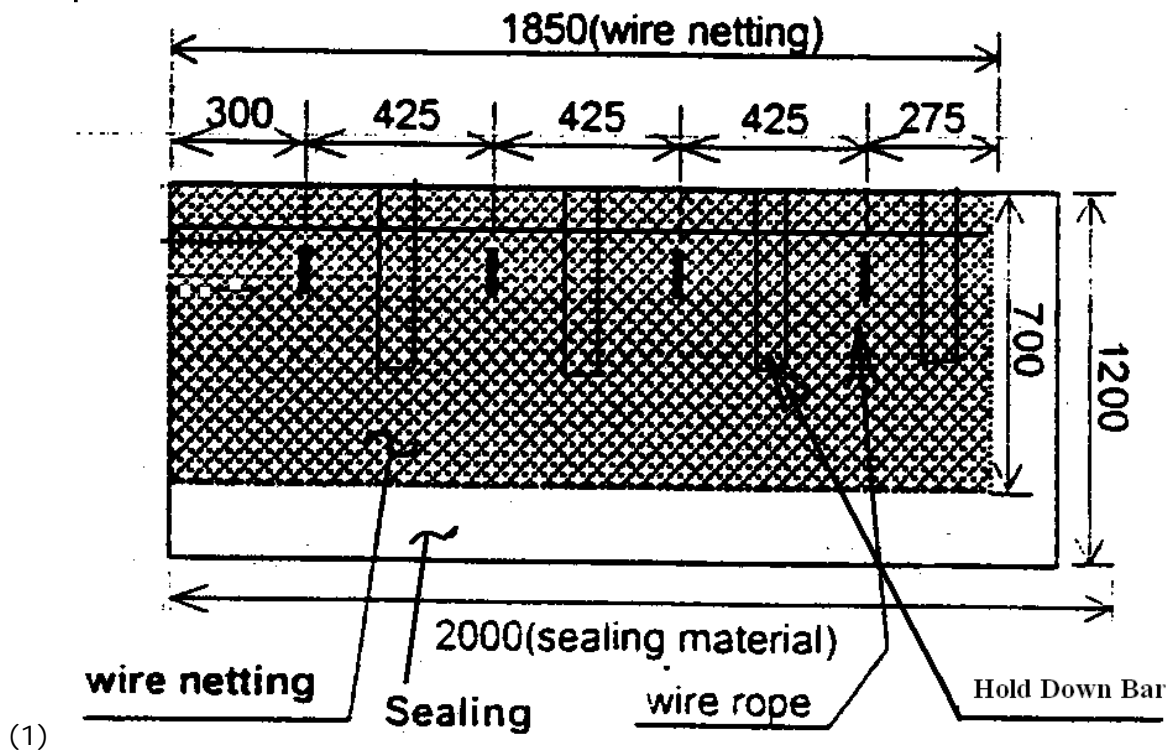
To install the gusset pieces between compression bar and roof, appropriate scaffolding to access gusset piece shall be provided for fit up and welding.

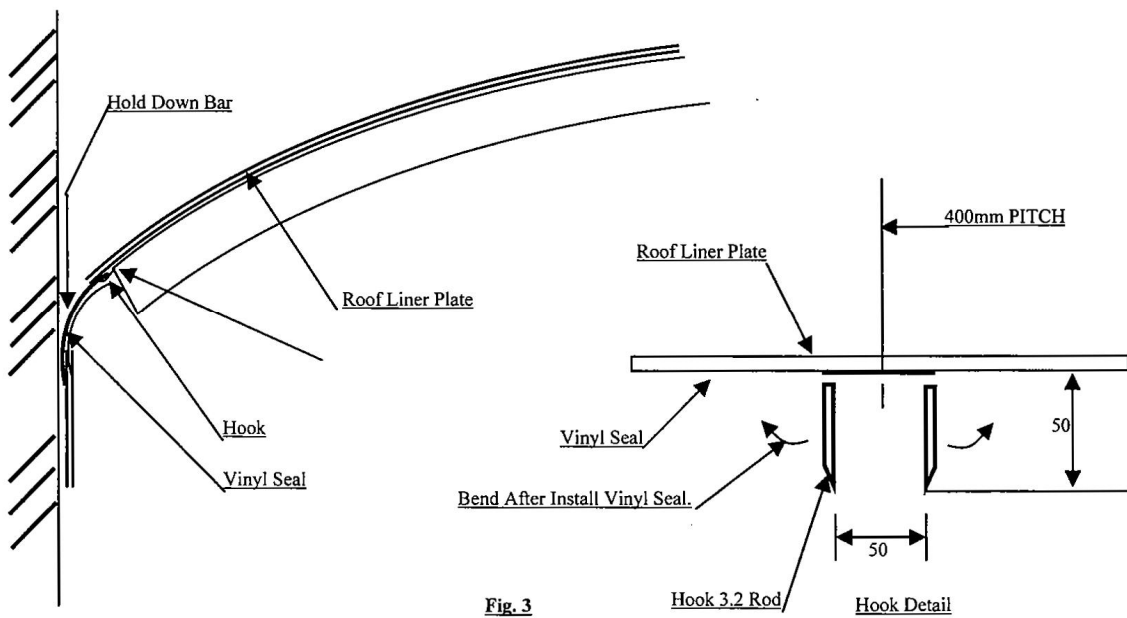
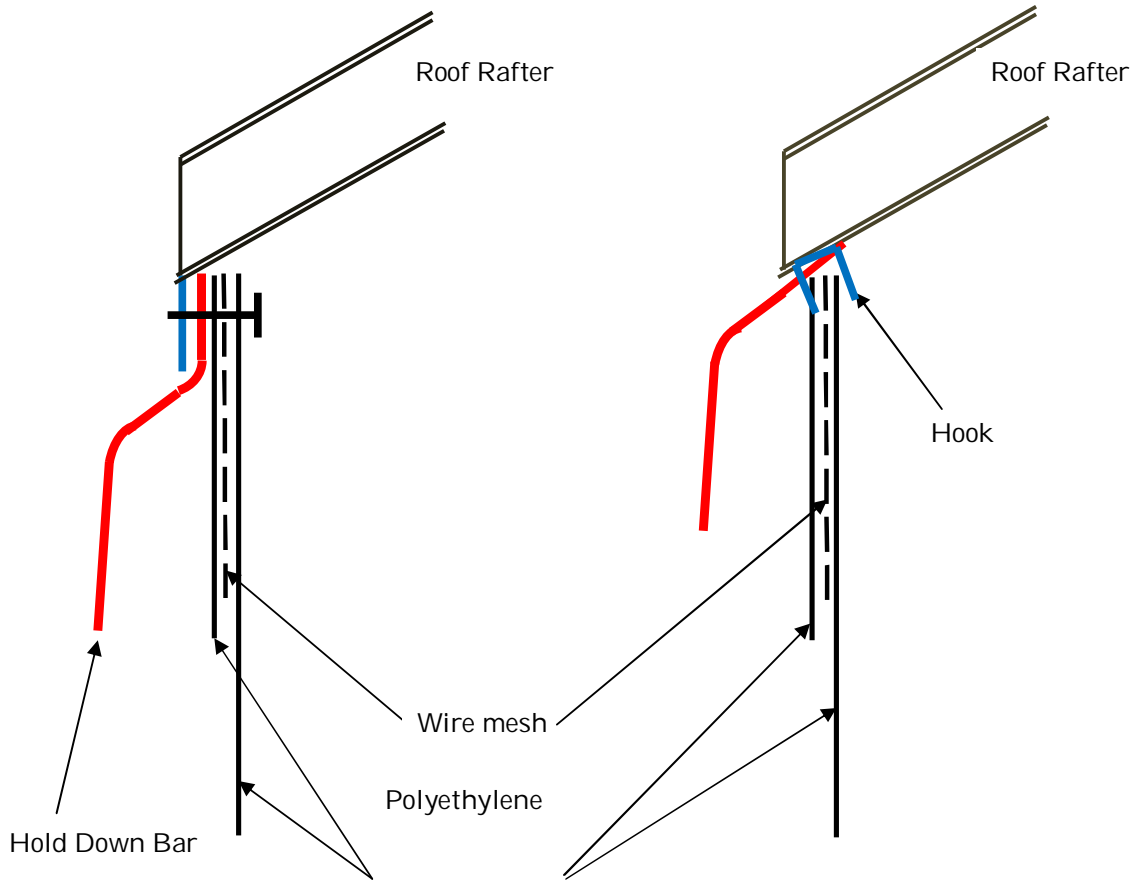
## 5.4 Arrangement of Blowers, Generators

- (1) 3 sets of blower and generators should be installed near the tank. 2 sets are for normal operation, and 1 set for stand-by. Standby blower are to be operated by one generator separately.  
Temporary electric power for construction should be prepared as for emergency power source.
- (2) Temporary air-duct should be installed from the blower area, via a roof manhole, to the bottom of the tank.

## 5.5 Installation of sealing system

- (1) Temporary roof and sealing material should be installed all around the space between the shell and the roof structure. The vinyl peripheral seal shall be installed around the perimeter as shown in Fig.2 and joints of vinyl seal shall be sealed with adhesive tape. This work should be performed after completion of hot work around there.
- (2) Guide rollers should be attached to the outermost of the roof in order to keep the gap between the shell and the sealing material constantly during the roof being raised up.
- (3) The other manholes and nozzles should be closed with valves and/or blind flanges.





**Fig. 3**



## 5.6 Arrangement of Measuring Equipments

- (1) Install a command post (commander room) for the purpose of central control and instruction during the air-raising period.
- (2) Install a measure system that can confirm the inclination of the roof structure by outputting data of 4 points of the roof level. All data should be measured at the same time. These personnel shall be have a separately walkie talkie. Commander shall be received data from each personnel every 5 minute to record the roof inclination.
- (6) As the pressure inside of the tank can be measured by utilizing the embedded piping for purging, 2 sets of manometer should be equipped from the flanges those have been arranged around the top of the tank shell. One manometer is to be set up in the command post and the other to be set up at the blower area.
- (7) Equip a communication system with wiring between the blower area and the command post in order to report the opening range of the damper to the recorder in the command post

## 5.7 Preparation for Roof Fixing Works

- (1) Mark basic points of angles ( $0^\circ$ ,  $90^\circ$ ,  $180^\circ$ ,  $270^\circ$ ) on the compression bar and mark a circumferential line on the outer surface of the roof. The line should be marked near the overlapped line between the compression bar and the roof plate, but to be shifted by some extent toward the tank center side in order not to be hidden when the roof is fixed.
- (2) Arrange necessary tools for the angular alignment of the raised roof such as levers, jacks, etc. on the top of the outer shell.
- (3) Arrange necessary jigs, tools and welding cables for the fixing works of the roof to the ring plate on the top of the tank appropriately.
- (4) Indicate working ranges on a round of the ring plate in order to show the split of works to each working team.

## 5.8 Others

- (1) Install a temporary stage close to the tank, and set up a temporary house on the stage. The temporary house is to be used as the command post.
- (2) Arrange cable telephones for the communication between the commander, the blower operator and the measurement group.
- (3) Arrange transceivers for the communication between the commander, the crane operators, the inspectors and the blower operator.

## 6. Preliminary Air-raising

### 6.1 Purpose

The purpose of the preliminary air-raising is to check and confirm the following conditions. The height to be raised up is within a range from 50mm to 100mm approximately.

- (1) Pressure in the tank at the starting of the air-raising, and pressure at the stoppage of the air-raising.
- (2) Sealing conditions
- (3) Balancing conditions of the roof structure
- (4) Operating conditions of the generators and the blowers
- (5) Conditions of the balance wires
- (6) Operability of the manometers, measuring equipment of the roof levels, the tension meters of balance wires.

### 6.2 Preparation

- (1) The commander and the measurement group should carry out their duties on the bottom of the tank during the preliminary air-raising period.
- (1) Arrange counter weights (steel plates) on the appropriate portions of the roof plates to adjust the weight balance.
- (2) Close the "Roof Opening for Construction"

### 6.3 Sequence of Temporary Air-raising

Time schedule for the preliminary air-raising should be prepared in advance, and all the persons in charge of the air-raising works should act to the commander's instruction.

- (1) Carry out necessary checks in accordance with a checklist that should be prepared in advance
- (2) Based on the organization chart, everyone should be in his position.
- (3) The commander should confirm the above (2), and instruct the blower operator to start the blowers.
- (4) The blower operator should start the blowers, and report to the commander that the blowers are ready for supplying air into the tank.
- (5) The commander should instruct the blower operator to supply air into the tank.
- (6) The blower operator should gradually open the suction dampers. The

commander should continuously inform the blower operator of the pressure in the tank.

- (7) The commander should instruct the measurement group and check group to confirm the conditions of balance wires and sealing portions. The measurement group and the check group should carry out the necessary checks and report the results to the commander.
- (8) After confirmation of the above (7), increase the pressure in the tank and raise the roof up to the height of a range from 50mm to 100mm approximately.
- (9) Check the necessary items.
- (10) After confirmation of the above (9), gradually close the suction damper and decrease the pressure in the tank.
- (11) After the confirmation of the roof structure landing on safely, shut both the suction dampers and the discharge dampers, and then stop the operation of the blowers.
- (12) When the roof inclination exceeds the allowable value, re-arrange the counter weight, and conduct the same procedure of the temporary air-raising works.

Item to be measured	Measuring portion	Measuring method	Control value
Roof inclination	Roof	Optical Distance Meter	80mm
Raising pressure	Top of the tank and the commander post	Manometer	
Tension of Wires	14 points	Tension Meter	1000kg

#### 6.4 Items to be confirmed after Preliminary Air-raising

- (1) Tension of the balance wire by tension meter
- (2) Checking of the damaged sealing portions and repairing, if necessary
- (3) Fuel check of the generators

### 7. Air-raising

#### 7.1 Precaution

- (1) The air-raising work should not be carried out in case of the following weather conditions.
  - When it rains, or it will rain soon.

- When the average wind speed exceeds 10m/sec
- (2) Any other works should not be carried out on the appointed day for the air-raising work.
  - (3) On that day of the air-raising work, before the start of the work, each responsible person should carry out the final confirmation based on each check sheet for each equipment/apparatus/tool that he takes charge of, and should report to the commander that there are no irregular conditions for them.

#### 7.2 Start of Blowers

- (1) After the final confirmation, each person should stand by in his responsible position.
- (2) According to the commander's instruction, start the blowers as the same manner as the temporarily air-raising.
- (3) Check conditions of sealing portions, balance wires and blowers during raising the pressure in the tank.
- (4) When the pressure in the tank reaches to the necessary raising pressure that has been measured at the preliminary air-raising, and the roof structure has actually started for floating, adjust the suction dampers to control the raising speed.

#### 7.3 Air-raising

- (1) When the roof reaches to a height of 500mm, check the roof inclination.
- (2) During the air-raising process, check the following items constantly, and confirm that there are no irregular situations.
  - pressure in the tank
  - height of the roof
  - balance of the roof
  - tension of the balance wires
  - conditions of the blowers and the generators

#### 7.4 Alignment of a Center of the Roof Structure

- (1) When the roof structures reaches to a height of 1,000mm lower from the designed level, narrow and adjust the suction dampers to keep the raising speed .
- (2) Continue the above raising speed until the roof structure reaches to a height of 200mm lower from the design level.
- (2) When the roof structure reaches to a height of 200mm lower from the designed level, narrow the suction damper smaller. Under the condition that the raising movement is almost stopped, measure the following dimensions by using the points and lines

- Lapping width at roof fixing
  - Difference of the center at roof fixing
- (4) If the measured data exceed the allowable values, adjust the roof structure by tools (such as levers, jacks, etc.)
  - (5) After the above adjustment, re-start the raising very carefully.
  - (6) When the roof touches to the ring plate, make the final confirmation of the roof alignment.
  - (7) Confirm that the roof plate and the ring plate are familiar with each other, and then adjust the suction dampers to let the roof structure stop and to keep the pressure in the tank constantly.

## 8. Roof Fixing

- (1) After the confirmation of the roof alignment, the roof fixing works should be started.
- (2) Arrange and weld the fixing jigs (58 sets)
- (3) Fix and weld the roof to the ring plate for the range of both sides by 400mm from the fixing jig.
- (4) After the welding mentioned above (3) has finished, decrease the pressure of the tank, and carry out the fixing and tack-welding works for the remaining parts.
- (5) After finishing the works mentioned above (4), decrease the pressure of the tank again, and carry out the welding for the remaining parts.
- (6) The inspectors should confirm that the welding has been finished according to the instructed drawings.
- (7) After the confirmation of above (6), gradually close the suction damper and decrease the pressure in the tank to 0mmAq. Remove the fixing jigs from roof plate/ring plate, and weld those portions between roof plates and ring plates.  
The operation of the blowers should be still continued to enable the pressure to increase at anytime.
- (8) After a confirmation that all of the welding works including the above (7) has finished without failure, stop the operation of the blowers and generators.  
The air-raising works are completed.

