

## Study on Cold Insulation Construction Technology of LNG Low Temperature Storage Tank Wall

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**Abstract.** The cold insulation construction of LNG low-temperature storage tank is the key process of construction of tank shell and the cold insulation construction of tank wall is both the key point and the difficult point of cold insulation construction. The cold insulation layer of tank wall has characteristics of complicated structure design, frequent overhead operation and high-standard installation, strictly abiding by stipulated procedure. Technique requirements during construction and solution to problems of safety and high efficiency during the entire process of construction and control of construction quality are important guarantees of carrying out cold insulation construction of LNG low-temperature storage tank wall smoothly. This paper cites simulation of cold insulation of LNG low-temperature storage tank wall as example and describes detail contents of structural characteristics of cold insulation layer of tank wall, construction procedures and construction methods.

### 1. Preface

LNG is abbreviation of liquefied natural gas. The gas field production of natural gas purification treatment, and then the ultra low temperature (-162 °C) liquefaction of the formation of liquefied natural gas. LNG colorless, tasteless, non-toxic and no corrosion, its volume is about one 600<sup>th</sup> of the amounts of gaseous natural gas volume, the weight is only about 45% of the parts of the water in the same volume. It is a very clean, environmentally friendly energy, LNG industry is developed rapidly in our country. LNG cold construction characteristics are: high workload, cross operations, hard construction, high risk operation[1]. In this paper, the simulation of LNG low temperature storage tank wall space for the construction of cold storage is taken as an example, we briefly introduce the LNG storage tank wall insulation construction technology.

### 2. General Situation of LNG Storage Tank Wall Cooling

Now spacing of mainstream large LNG storage tank inside and outside of the tank wall are 1 meter, cold insulation structure are: tight next to the tank wall lateral 300mm thick elastic mat (four), residual annular space filled with perlite, elastic mat and perlite used between glass fiber cloth isolation. Major insurance cold materials used include: sticking nails, elastic mat, glass fiber cloth, perlite powder.

### 3. Simple Flow of Cold Construction for LNG Storage Tank Wall

Insulation nail position identification→insulation nail installation→the first layer of the elastic mat installation→the second layer elastic mat installation→the third layer of elastic mat installation→the four layer elastic mat installation→glass cloth installation→perlite filling →perlite vibration.

### 4. Simulation Test Purposes

#### 4.1 Assembly Research

- (1) Maneuverability of cold construction of nacelle in annular space;
- (2) Study whether the vibrating mechanism satisfy the vibration requirements of perlite;
- (3) Study on the distribution of vibrating mechanism to ensure the wiring is reasonable and safe;
- (4) Study whether the overall effect of the basket and vibrating mechanism satisfy the construction requirements.

#### 4.2 Optimization of Construction Scheme

- (1) Optimization of the installation of heat insulation nails and elastic felt installation program;
- (2) Optimization of perlite filling and vibration construction scheme;
- (3) Master the entire construction process, construction tools and methods of the LNG storage tank by simulation test.

### 5. Simulating Test Cell Production and Cold Preservation Construction Method

#### 5.1 Test Tank Production

Considering spacing inside and outside wall of the tank is 1m in large LNG storage tank, test in length×width×high=5m×1m×4m steel groove on the tank wall insulation nail installation, insulation cotton installation and perlite filling are three most important process of the construction contents of simulation test.

#### 5.2 Construction of Heat Insulation Cotton in Test Tank

##### 5.2.1 Construction Process

The heat preservation nail position mark→the first layer of elastic felt→ the first layer of elastic felt→ the first layer of the gasket→the second layer of elastic felt→ the second layer of the gasket→the third layer of the elastic mat→the third layer of the gasket→the fourth layer of elastic felt→glass cloth installation

##### 5.2.2 Process Requirements:

- (1) According to the construction drawing, thickness of elastic felt is 300mm, there are 4 layers of 75mm thick elastic felt in total.
- (2) Insulation nail paste position identification: all to protect the cold trough surface after the completion of the necessary preparations in accordance with the requirements of the drawings, the outer surface of the tank wall with white chalk mark insulation nail the installation position of the tank wall sticking nail polish or scrub clean surface should be clean and free of dust, rust, grease, oil should be cleaned by solvent to remove grease and bonding.
- (3) After the installation insulation nail is completed install the elastic mat according to the construction drawings (as shown in Figure 1) requirements. Elastic felt before and after the installation of the adjacent two layers ladder fault seam 300mm, with elastic layer felt butt joint installation and elastic mat block should be closely docking, there shall be no gap layer between the joint should be staggered 100mm to break glass cloth, and one end of the elastic mat on the joint should be staggered at least 150mm, broken glass cloth lap width will be no less than 150mm. Glass cloth lap at applying glue cement to prevent expansion perlite into the inner layer of the elastic mat. If we meet problems such as tank uneven uniform elastic felt there is a gap, we will use small elastic

felt filling for compacting; In installation, the inside elastic felt rings should be slightly compressed to ensure minimum longitudinal seam on the outermost layer.

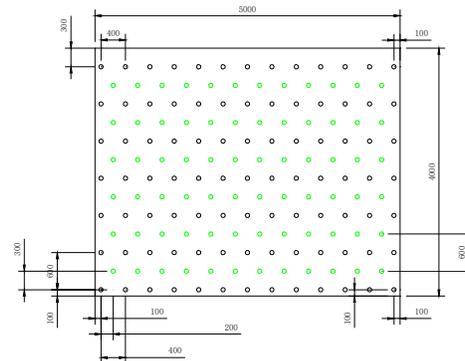


Figure 1. Layout of insulation nail in experimental slot.

(4) The outermost layer of the elastic mat surface is covered with glass cloth ring, width between the two adjacent glass cloth lap is 50mm, after each lap of a glass cloth using 75mm wide aluminum membrane adhesive tape from top to bottom in turn sealed paste, no shedding phenomenon, this work can be carried out on the basket. The basket move up and down as soon as the elastic mat in the tank wall of the installation of cold insulation nail on the elastic felt close to the moving process of the tank wall, be careful not to be scratched by cold nails in the construction.

(5) After glass cloth laying is completed, in the lateral added a layer of flat steel with elastic fixation mat (Fig. 2), flat steel will be fixed on the insulation nail by lateral nut.



Figure 2. Construction effect of field test of elastic felt.

(6) Insulation nail marking in high position, pasting insulation nails, and elastic felt laying processes are carried out on the basket, basket structure schematic diagram are shown in Fig. 3.

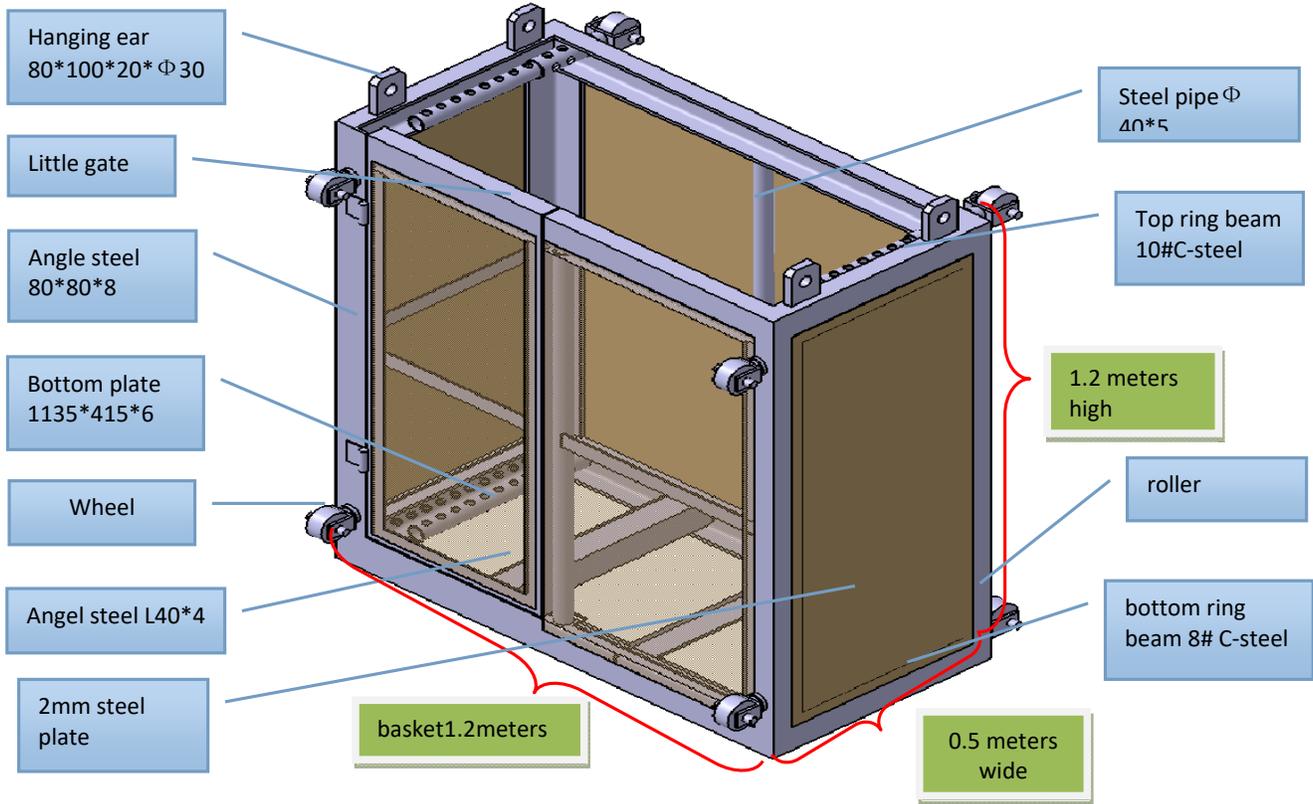


Figure 3. The tank wall cold preserving filling basket.

### 5.3 Construction of Filling Test tank with perlite

#### 5.3.1 Perlite Filling

According to the construction experience and relevant technical data of the scheme ,perlite filling height is 3.25 m, using artificial filling method the test groove. After complete filling of the vibrator for vibrating, we estimate perlite sedimentation height.

#### 5.3.2 Perlite Vibrator

Perlite installation requires vibrators works when filling to 3.25m high. Vibration device suspend from the hoist, hoist on the test day workshop hanging rail slide can achieve the level of vibration of mobile devices, as well as electric hoist cables can be moved up and down vibration control device. Electric hoist hanging under a vibrating plate, vibration plate adopt 1.5×1.8 meters 6mm plate. A vibration motor is installed in the middle of whole vibration plate, while the vibration plate side corners each equipped with a rubber tire, acts as a stopper to prevent equipment damage the elastic vibration felt. Control electric hoist, the vibrating device is embedded within the perlite, start vibrators, vibrating plate starts vibrating, they achieve perlite vibration, subsidence.

When vibrated, the workers divided into two groups, each group has two people. One group standing on the edge of the trough, responsible for operating the vibrator means taking off and landing aircraft button to adjust the height of the vibration plate while vibrating the annular space below the regulatory safety of workers; another group of workers standing in charge of work on the basket vibrators, a worker control gondola lift button to make the gondola down to the height of the annular space corresponding to vibration operation, another worker control buttons to control the motor vibration plate which was vibrated on the operation (on the vibrator plate the motor supply line has been led to the gondola station workers), as shown in Fig. 4.



Figure 4. Vibrating construction.

### 5.3.3 Test Results

In accordance with the requirements of the vibrating height decreased by 15% ~ 27%, results satisfy the requirement. Equivalent measuring method is in the height range of 3.25m after perlite vibration, the perlite's height should be from 0.53 to 0.94m, lower than before being vibrated, results satisfy requirements of [2].

The test estimates that after two hours perlite vibrated by a high thick sedimentation from 3.25 to 2.71 meters, for a total settlement of 0.54m, sedimentation rate was 16.62%, satisfy the requirements of vibrators, vibrators settlement perlite graph is shown in Fig. 5. Table 1 is perlite vibrator settlement data recording sheet.

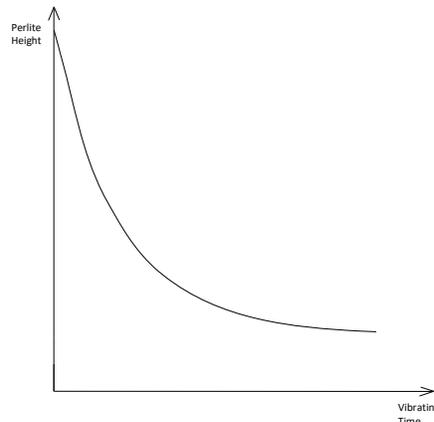


Figure 5. Vibrating curve perlite Settlement.

Table 1. Data record of perlite vibrating subsidence.

Serial number	Vibration date	Vibration time	Phase vibration time (minutes)	Cumulative vibration time (minutes)	Perlite height (m)	Stage sedimentation height (m)	Accumulated sedimentation height (m)	Cumulative sedimentation rate
1	2015.12.3	9:22	0	0	3.25	0	0	0
2	2015.12.3	9:22-9:38	16	16	3.17	0.08	0.08	2.46%
3	2015.12.3	13:40-13:51	11	27	2.98	0.19	0.27	8.31%
4	2015.12.3	14:10-15:00	50	77	2.88	0.1	0.37	11.38%
5	2015.12.4	8:25-10:25	120	197	2.73	0.15	0.52	16%
6	2015.12.4	13:50-15:30	100	297	2.71	0.02	0.54	16.62%

## **6. The Key Control Points of the Wall Insulation Construction**

### **6.1 Construction of Elastic Felt**

- (1) Examine the drying and dust removal of the outer surface of the inner tank wall;
- (2) Check whether the bond strength and bond density of the heat insulation nail satisfy the design requirements [3], [4];
- (3) Check whether the elastic mat butt joints staggered distance between layers closely, satisfy with technical requirements;
- (4) Check the surface roughness of the elastic felt;
- (5) Inspect distance between glass cloth and felt elastic joints, whether glass lap width and bond strength satisfy the design requirements.

### **6.2 Perlite Filling Cold Insulation[5]**

- (1) The vibration test data collection and sorting of perlite;
- (2) The overall assembly and operation of the vibrating equipment;
- (3) Record perlite vibration settlement data timely, verify whether the vibration effect satisfy the design requirements.

## **7. Conclusion**

Through the walls of the tank holding cold test on the tank wall insulation nail installation, insulation cotton installation and perlite filling are three key processes of construction simulation and test in the installed program research and optimizations has made remarkable achievements. Proving that our company has mastered the LNG storage tank wall insulation construction technology, future LNG tank wall insulation construction will provide reliable technical reserves and scheme support, and lay a solid foundation for the company's future participation in the construction of LNG storage tank in China and abroad.

## **References**

- [1] Zhong-Li Yuan, Lun-Jiang Yan. LNG low temperature storage tank design and construction technology [J]. Petroleum Engineering Construction, 2007, 33 (5).
- [2] GB 50645-2011 [2], Construction Quality Acceptance Specification in Petroleum Chemical Engineering [S].
- [3] SH/T 3522-2003 [3], Construction Technology Standard in Petroleum Chemical Insulation Engineering [S].
- [4] Yi Fan. A cold storage solution for outer wall of the inner tank of the LNG storage tank [J] Enterprise Technology Development, 2014, No. 2.
- [5] 03010EQ-DP60-0106, Expanded Perlite Technical Requirements [S].
- [6] Junwei Yan, Zhaoci Li. LNG low temperature pipe precooling process numerical simulation, Low Temperature and Superconductivity, No. 9.