Organization of the fuel heating reserve system on the basis of associated petroleum gas

D S Balzamov, E Yu Balzamova, V V Bronskaya and O S Kharitonova

1Department of Power Supply of Enterprises and Energy Resource Saving Technologies, Kazan State Power Engineering University, 51 Krasnoselskaya St., Kazan 420066, Russia
2Department of Chemical Process Engineering, Kazan National Research Technological University, 68 Karl Marx Street, Kazan 420015, Russia
3Department of Chemical Technology of Petroleum and Gas Processing, Kazan National Research Technological University, 68 Karl Marx St., Kazan 420015, Russia
4E-mail: olga.220499@mail.ru

Abstract. The use of associated petroleum gas as the main and reserve fuel is a promising direction because of its cheap compared to natural gas. There is the possibility of using associated petroleum gas as a reserve fuel for the regional heating station at the article. Projects on joining associated petroleum gas pipeline to the existing gas pipeline are presented.

1. Introduction
The possibility of the organization of the fuel heating station reserve system is considered. The associated petroleum gas is intended to be used as a reserve fuel for the preparation of which the construction of a gas separator and gas metering unit site is planned. The drainage tank with a volume of 8 m³ is provided for the condensate removal after the separator.

An analysis of the relief was carried out for the construction of the site. The result was that the relief is calm with a total gradient of 0.02 in the southeast direction. The absolute mark is within 206 - 205 m.

The main factors that have the greatest impact on the site placement [1-6] are determined:

• the conformity of the location of the main and additional units with the technological production flow diagram;
• accounting the location of existing units;
• performing design standards.

The following initial data have been adopted for the development of the technical solution:

• Required gas consumption — 8000 m³/hour;
• gas pipeline of associated petroleum gas (APG) — above-ground diameter is 159/219 mm, pressure is 0.2 – 0.4 MPa;

An analysis of the APG composition has been carried out, the results of which are presented in table 1.
Table 1. Fractional analysis of APG.

| Composition (volumetric concentration,%) | APG  |
|------------------------------------------|------|
| Hydrogen sulfide                         | 0.01 |
| Carbon dioxide                           | 0.41 |
| Oxygen                                   | 0.07 |
| Nitrogen                                 | 9.06 |
| Methane                                  | 35.86|
| Ethan                                    | 17.47|
| Propane                                  | 22.98|
| i-butane                                 | 3.02 |
| n-butane                                 | 7.01 |
| i-pentane                                | 1.31 |
| n-pentane                                | 1.34 |
| Hexane and higher hydrocarbons           | 1.46 |
| Gas density ($t=20^\circ C$, $p=101.3 \text{ kPa}$), kg/m$^3$ | 1.61 |

The proposed technical solution for the organization of the fuel heating station reserve system of the heating networks enterprise (HNE) implies the construction of a gas pipeline-jumper between the above-ground APG pipeline and an underground natural gas pipeline [7-11].

Construction of the gas pipeline-jumper is provided in case of emergency disconnection of the natural gas supply to the heating station of the HNE from the gas distribution point. The technical solution provides for the construction of the following units:
- net-shaped vertical gas separator with a volume of 4 m$^3$ and a capacity 19500 m$^3$/hour. The liquid content of the gas separator shall not be more than 200 cm$^3$/m$^3$. The gas separator fluid jetting is not more than 20 cm$^3$/1000;
- underground tank;
- commercial APG metering unit;
- disabling valves on existing gas pipelines.

2. Materials and methods

The proposed scheme for connection of the APG gas pipeline to the HNE heating station is presented on Figure 1.

![Figure 1. Diagram of connection of the APG gas pipeline to the heating station.](image)

According to the scheme presented in Figure 1, the associated petroleum gas is sent from the gas pipeline from the intake point to the vertical gas separator for cleaning. Block valves 1, 6 are installed...
on the gas pipeline for the possibility of supplying gas to the vertical gas separator. The scheme also provides for the installation of two stop valves to verify the trim impermeability of the ZKL 150-15 valve. A manometer is established between the valves. According to its indications the reliability of the valve trim impermeability is determined. When block valves 1 and 6 are closed and valves 2 and 3 are open, the gas is supplied to the vertical gas separator. After cleaning from condensate, the gas enters the commercial gas metering unit. The flowmeter IRVIS-RC4-PP-PPS-150 with a diameter of 150 mm is installed as a commercial gas metering unit. A gas filter FG-50F, which is designed to purify gas from mechanical impurities, is installed in front of the gas meter. After cleaning and measurement, gas is supplied to the natural gas pipeline with diameters 377x8 mm. Three valves are installed to supply gas to the natural gas pipeline: stop valves 5 and 7 are installed on gas pipelines with a diameter of 219 mm and 377 mm, valve 4 is installed on the pipeline-jumper with a diameter of 219 mm. When supplying associated petroleum gas to the heating station of the HNE, the valves 5 and 7 must be closed and the valve 4 must be opened [12-16].

A hand-operated valve is installed at the outlet of the condensate from the vertical gas separator. The condensate released in the vertical gas separator enters the drainage tank. Condensate is drained manually by the signal of the upper limit of condensate sensor in the gas separator. The lower limit of condensate in the gas separator is determined visually by the signal lamp. Condensate from the drainage tank is removed by road.

3. Results

The designed gas pipeline is related to the second category. The thickness of the gas pipeline wall is determined by the formula:

$$\delta = \frac{nPD_o}{2(R_1+nP)}$$  \hspace{1cm} (1)

where $n = 1.4$ is the load effect factor for the above-ground gas pipeline;
$P = 0.4$ MPa is working pressure in the gas pipeline;
$D_o$ is the outer diameter of the gas pipeline, cm;
$R_1$ is calculated tensile strength, MPa, which is determined by the formula (2)

$$R_1 = \frac{R_1^n m}{K_s K_p}$$  \hspace{1cm} (2)

where $R_1^n = 333$ MPa is the normative tensile strength of pipeline metal and welded joints that is equal to the value of the time resistance $\sigma_{\text{time}}$.

$m$ is the pipeline working condition coefficient. For the 2nd category gas pipeline $m = 0.75$;
$K_s = 1.55$ is the material resistance factor;
$K_p = 1.0$ is the pipeline purpose effect factor;
Calculations were performed in accordance with the dependencies given in table 2.

| Table 2. Calculation results. |
|-----------------------------|
| **Initial data for calculation** | №1 | №2 |
| Pipeline material brand | K-34 | K-34 |
| Working (normative) pressure, MPa | 0.4 | 0.4 |
| Outer pipe diameter, mm | 159 | 219 |
| Load effect factor | 1.4 | 1.4 |
| Working condition coefficient | 0.75 | 0.75 |
| Load effect factor | 1.55 | 1.55 |
| Pipeline purpose effect factor; | 1 | 1 |
| Normative tensile strength of pipeline metal, MPa | 333 | 333 |
| Calculated wall thickness, mm | 0.2753 | 0.3792 |
Corrosion allowance, mm

Accepted pipeline wall thickness, mm

For pipelines whose steel has a ratio of specified minimum yield strength to time resistance less than 0.75, the pipeline wall thickness is further calculated by expression (3) [17-20]:

$$\delta = \frac{n_i P d_o}{2(C_b a R_{2n} + n_i P)}$$

where $n_i = 1.25$ is for the 2nd category gas pipeline;

$C_b = \frac{b_{\text{min}}}{b}$ is the ratio of the minimum permissible pipeline wall thickness to the nominal pipeline wall thickness;

$a = 0.95$;

$R_{2n} = 206$ MPa is the normative resistance to the tension of pipeline metal and welded joints that is equal to the yield limit. The yield limit for steel of the strength class K34 is 206 MPa, the time break resistance is 333 MPa [21-24].

Equivalent strain in pipeline walls is calculated by the formula [7-9]:

$$\epsilon = \frac{P_t d_o}{d_i - d_o}$$

$P_t = 0.5$ MPa is the pipeline test pressure;

d_0 is the outer diameter of the pipe, mm;

d_i is the inner diameter of the pipeline, mm.

4. Conclusion

Organization of the fuel reserve system based on associated petroleum gas allows to improve the reliability of functioning the heating station and, as a result, ensure uninterrupted heat supply to the consumers of the settlement.

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