P a r t 3

ASH AND SLAG HANDLING

3.2. Ash and slag handling systems at TPPs

3.2.2. Ash removal

3.2.2.13. Air dedusting technologies and equipment for pneumatic conveying plants transporting fine bulk materials

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In the paper a brief overview of the major technologies for separating dust from dust and gas flows is provided. Various classifications of dust separation devices are described. Main characteristics of devices for purification of dusty air of pneumatic conveying plants and their applications are presented. Brief results of analyzing the applicability of different air dedusting technologies and equipment for installations for pneumatic conveying of ash and coal dust of TPPs and other fine bulk materials are given.

1. BRIEF CHARACTERISTICS OF DUST REMOVAL EQUIPMENT

One of the most important sanitary tasks, arising at pneumatic conveying of bulk materials, is to provide the norms of a maximum permissible concentration of dust particles in the air discharged from pneumatic plant into the environment. Therefore, dust separation equipment is an integral part of installations for pneumatic conveying of fine bulk materials.

According to [2] the air dedusting process in general includes the following stages:

- preventing the spread of the "original" aerodisperse system in ambient air and increase in the system stability in the direction of a strictly limited predetermined area (dedusting process);
- destruction of a dust aerosol, is to separate dust from air (dust purification process);
- further reduction of dust aerosol stability, preserved after implementation of the previous steps, consisting in the intensification of spreading the remaining dust particles in the air and aeration of the dispersion medium in the atmospheric boundary layer (dust dispersal process).

Each stage of the air dedusting process provides the introduction of artificial aerodisperse systems or the arrangement of directed external force fields. Each stage of the process can be implemented by different methods (aerodynamic, hydrodynamic, electromagnetic, thermophysical, mechanical, etc.), which are determined by a character of the directed external impacts on the dust aerosol.

There are various options of dust removal devices classification. For example, authors [1, 2] proposed the classification of dust removal devices, based on a use of the following methods of separation from dusty flows: dry mechanical gas cleaning; wet gas cleaning; gas filtration; electric gas cleaning.

Each of these methods has certain scope and application. Basically, they are based on one or a combination of several dedusting processes: deposition, separation, collection, etc.

The basis of dry methods (Table 1) make gravitational, inertial, centrifugal mechanisms of deposition as well as filtration mechanisms. When using wet methods, gas is cleaned by close interaction between fluid and dusty gas on a surface of the gas bubble, drops or a liquid film. Electric gas purification is based on ionization of gas molecules by the electric discharge and charging of particles suspended in gas.

The air and gas cleaning system may contain equipment of several types, connected in a serial chain to increase the efficiency of dust collection. Dust separation equipment, wherein the dust separation from the air flow is performed sequentially in several steps, which differ in principle, design features and the cleaning method, is referred to the combined dust collection equipment.

Table 1. **Groups and types of equipment for collecting dust using dry method**

Group of equipment	Type of equipment	Field of application	
		Air filters	Dust collectors
Inertial	Chamber	-	+
	Louver	-	+
	Cyclone	-	+
	Rotary	-	+
Gravity	Hollow	-	+
	Flange	-	+
Filter	Fabric	-	+
	Fibrous	+	-
	Grain	-	+
	Reticulate	+	-
	Spongy	+	-
Electric	One-zone	-	+
	Dual-zone	+	+

Note. Symbol "+" means application; "-" means non-application.

Any system intended for cleaning dusty air and gas may contain equipment of one or more types connected in a derail chain for achieving the desired dust collecting efficiency. Dust collecting equipment, wherein the dust is separated from the airflow sequentially in several stages that differ in principle, by construction features and purification methods, is referred to a combination of the dust collection equipment.

When processing emissions, containing solid aerosol contaminants, as a rule, it's possible to reach low breakthrough values (less than 2%) only by two-step purification. For pre-cleaning of dusty gases in the power sector dust precipitation chambers, cyclonic devices, and for the final cleaning - ESPs, wet dust precipitators or bag filters are mostly used. Recently porous filters have been also applied.

Wet cleaning methods (Table 2) have a significant drawback - the need for separation of the captured pollutant from the catching liquid. For this reason, wet methods should be applied only in the absence of other purification methods, giving the preference to the ones with a minimum fluid flow rate.

Table 2. **Groups and types of dust separation equipment for dust collecting using wet method**

Group of equipment	Type of equipment	Field of application	
		Air filters	Dust collectors
Inertial	Cyclone	-	+
	Rotary	-	+
	Scrubber	-	+
	Crash	-	+
Filter	Reticulate	+	-
	Foam	-	+
Electric	One-zone	-	+
	Dual-zone	+	+
Biological	Bio-filter	-	+

Note. Symbol "+" means application; symbol "-" means non-application.

Dust removal equipment in all its diversity, can be classified by a number of the major defining characteristics: purpose, the main mode of operation, design features, efficiency, etc.

In accordance with [3], dust separation devices are divided into five classes, depending on the size and the particle collection efficiency (see Table 3).

Table 3. **Classification of dust removal devices**

Class of the device	Sizes of effectively collected particles, microns	Dust efficiency by mass, at dust dispersion groups				
		I	II	III	IV	V
I	below 0,3	-	-	-	80…99,9	<80
II	above 2	-	-	92…99,9	45…92	-
III	above 4	-	99…99,9	80…99	-	-
IV	above 8	>99,9	95…99	-	-	-
V	above 20	>99	-	-	-	-

Note. Limits of effectiveness correspond to the boundaries of zones of dust classification groups.

Often depending on the collection efficiency, the machines are divided into two groups: coarse dust and fine dust separation. However, the concept of coarse dust and fine dust control are relative, depending on the type of production and dedusting purposes.

Currently there are various methods and apparatus for collecting the particulate impurities from the air. Valdberg A.Y. [4] proposed the following classification of dust-collecting devices: dry mechanical (gravity, inertia), filtering, wet and electric apparatus (ESPs). The main representatives of inertial dry dust collectors include louver devices, single and multiple cyclones, multicyclones and wet - hollow and packed scrubbers, foam, shock-inertial action devices, Venturi scrubbers. Porous filters are varied by the filter material (filters made of fibrous woven and nonwoven materials, compacted by metal and ceramic metal powders; metal and plastic bags), and then - by design, size and private grounds. In ESPs the main distinguishing feature is a horizontal or a vertical direction of the process stream.

Equipment selection when creating dust-collecting system depends on the specific requirements of production and physical and mechanical, physical and chemical properties of the dispersed particles.

The concept of classifying separator of particulate matter, proposed by A.I. Pirumov [5] is based on the principle of separation of dust collectors into classes according to the sizes of effectively collected particles. This classification provides substantial assistance in the choice of dust collection means.

According to the opinion of V.N. Uzhov [6] division of precipitators into groups is somewhat arbitrary, because the separation of suspended solids from gas in any dust collecting device is almost always under the influence of several forces. For example, in the centrifugal scrubber dust particles are not only caught by water, but are trapped due to its centrifugal force. In the inertial dust collector not only the inertia forces are active, but in most cases, the force of gravity acts as well. However, a major factor of dust collection in the centrifugal scrubber is water and in the inertial dust collector it's the force of inertia, occurring when changing the direction of the dusty flow.

Thus, the conventional division of precipitators into groups is made by the main and defining (but not unique) dedusting feature.

2. KEY FEATURES OF THE DUSTY AIR CLEANING APPARATUS

According to [2] key performances of equipment for cleaning the aerosols from the suspended particles include efficiency (degree) of air dedusting, hydraulic resistance and the cost of cleaning. General parameters of dust collectors also include their performance of the purified gas and power consumption, determined by the amount of energy consumption required to purify 1000 m^3 of gas.

Assessing the effectiveness of dust collectors the following should be taken into account:

- overall dedusting efficiency, or the amount of dust collected in the dust collector with respect to the amount of dust contained in the gas to be dedusted;
- particle size efficiency, determining the completeness of collecting the particles of a certain size, expressed in per-

centage of dust particles of a certain size separated in the dust collector;

- residual dust content in gas at its outlet from the dust collector;
- distribution of dust residue in gas by particle size or speed-fall.

In addition, a significant factor for evaluating the performance of dust collectors is energy consumption, and while selecting this or that dust collector type - frequency of distributing the particle fineness groups.

The degree of gas purification depends on the nature of particles and their sizes.

There is an overall degree of gas purification, which refers to the entire weight of particles, and the fractional gas purification degree separately for each fraction.

The degree of gas purification or dust collector efficiency is determined by the ratio of the mass of dust, captured in the apparatus, to the weight of dust coming into it.

Dust separation equipment performance is characterized by the amount of air, cleared per 1 hour. Apparatus, in which air is purified by passing through a filter layer, are characterized by specific air load, i.e. the amount of air, passing through the filtration surface of 1 m^2 per 1 hour.

Hydraulic resistance is essential, since its value influences the desired pressure of the fan, and consequently, the electricity consumption. It's measured by the difference of the total head at the inlet and outlet of the unit.

Energy consumption largely depends on the hydraulic resistance of apparatus. However, in ESPs electricity is mainly consumed on creation of the electrostatic field. Electricity consumption in single stage cleaning is within 0.035 ... 1.0 kWh per 1000 m^3 of air. Specific energy costs for removal of particulate impurities increase proportionally to the decrease in concentration of suspended particles in the stream, because a degree of purification in the dust collecting apparatus is essentially independent of the initial concentration of the pollutant. In addition, the unit costs are increasing with decrease in particle size.

In recent years, one of performances of dedusting devices became specific power costs, spent for a particular dedusting process realized in various ways. The so-called energy efficiency is used as an indicator of energy balance similar to the coefficient of efficiency.

Energy coefficient does not consider thermodynamic losses, such as those associated with non-isobaric real thermal process that accompanies the dedusting process. Therefore, a comparative assessment of the efficiency of dedusting systems only by energy efficiency can't be considered always justified. This approach is valid for reversible thermodynamic processes.

Cost of dedusting is one of the most important indicators, since it characterizes the efficiency of purification. It depends on many factors such as: capital equipment costs, operating and other costs. Cost of cleaning the air in different apparatus is significantly different and is determined, first of all, by requirements for clean air at the outlet of the dust separation installation. As a rule, more effective cleaning is much more expensive. If the cost of cleaning of a certain amount of air in a relatively simple apparatus such as high performance cyclone is taken as 100%, the cost of cleaning of the same quantity of air in the cyclone makes 120%, in a cyclone with a water film - 130%, in VTI scrubber - 140 %, in an electrostatic precipitator - 220% in a fabric filter (depending on type) it is from 260 to 280%. Two-step purification under the scheme "battery cyclone →ESP" makes about 330%.

According to the opinion of G.M. Gordon and I.L. Peysahov [7] ESP work can be assessed in two ways. In the first one, the specific mass content of dust in the cleaned gas is taken into account. This value is important to account for dust losses, and to represent the subsequent pollution of the environment as a result of dedusting system operation.

The second method of the dust collector operation evaluation is a relative one. It shows the proportion of dust, collected in the dust separator out of the amount that has gone into it with gases. This value is called a degree of the dust collector efficiency and is marked as η.

V.N. Uzhov [6] believes that the work of any dust collecting apparatus is characterized by the following technical and economic indicators:

- a degree of gas purification, otherwise known as dust collector efficiency factor, or gas purification factor;
- hydraulic resistance of the apparatus;
- specific costs of electricity, as well as compressed air, water, etc.;
- cost of the device;
- cost of cleaning.

According to [8] the major technological index of the filter operation is a degree of purification (efficiency) of dust collecting. Efficiency of the filter operation is characterized by residual dust content as well, as even a very high degree of purification (about 99%) does not guarantee compliance with sanitary standards in case of significant input dust content.

Economic performance indicators of the filter device are defined by capital and operating costs. Capital expenditures include: expenditures for the purchase of the main and auxiliary equipment, steel constructions, building materials and the cost of construction, installation and commissioning works; operating costs include: cost of energy resources (electricity, water, steam, compressed air), cost of purchase of supplies (filter plates, sealing materials, etc.) and products, salary of the operating personnel with charges, depreciation, craft and works general expenses less the value of collected product.

Technological parameters of the filter operation include: performance or throughput capacity, gas temperature, input and residual dust content, specific gas load by filtration or filtration rate and specific gas load during regeneration, hydraulic resistance, flow and pressure of the purge gas, duration and periodicity of regeneration, duration of filtration cycle and duration of the filter regeneration. Table 4 shows the main characteristics of different types of dust collectors for units of dry ash shipment (UDAS), plants for pneumatic conveying of the ash and pulverized coal at thermal power plants, as well as other fine bulk materials.

Vatin N.I. and Strelets K.I. [9] in their work note that the cleaning efficiency is the most important characteristic of the device, but for the complete characterization of the dust collector fractional efficiency is to be known. It shows the proportion of the collected dust for each fraction. This allows to select the dust collection equipment in accordance with the fractional composition of the dust.

CONCLUSION

The analysis of types of classifications and basic characteristics of dust separation equipment, influencing the choice of apparatus and dust separation technology, resulted in the following main conclusions:

1. No single point of view of various authors relating to the classification of dust separation equipment and dust separation method.
2. Whatever the differences in classifications of dust separation equipment and methods of air dedusting the authors considered the following common dust separation devices:

- degree of purification;
- performance;
- dimensions;
- weight;
- restrictions on use;
- field of application of devices.

3. To facilitate the choice of technologies and devices for purification of dusty air in ash pneumatic conveying plants of various capacities it's necessary to develop the selection criteria for dust separation devices.

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Table 4. **Main characteristics of different dust collectors for plants of pneumatic conveying the ash and pulverized coal at TPPs and other fine bulk materials**

Type	Mark	Manufacturer	Efficiency, %	Performance, m^3/h	Dimensions, m,	Weight, kg	Water consumption	Restrictions on use	Field of application of devices at TPPs
Dry cleaning									
Inertial cyclones	SCN-40	JSC “ENERGOMASH”, Russia	91…94	330…7730	D=3000…10000, H=12100…44680	33…139	—	allowable gas temperature at the inlet - 400°C	UDAS, intermediate hoppers
	VZP-M	LTD “BentSnab M”, Russia	98…99	1000…20000	D=200…1200, H=1100…6840	52…1800	—	optimal flow velocity - 3,5 м/с	UDAS, intermediate hoppers
	SDK-TSN-33	LTD “SZGO”, Russia	75…98	1100…63600	D=400…3000 H=1538…11215	46…2490	—	allowable gas temperature at the inlet – below 250°C	UDAS, intermediate hoppers
	TSN-24	JSC “ENERGOMASH”, Russia	88…98	2000…114400	D=400…3000 H=1704…12780	84…4725	—	allowable gas temperature at the inlet - 400°C	UDAS, intermediate hoppers
	TSP-2	JSC “TYAZHMASH”, Russia	86…91	17000…230000	D=1400…42500 H=6129…18095, L=700…2120,	2100… 24840	—	allowable gas temperature at the inlet - 400°C	UDAS, intermediate hoppers
Centrifugal cyclones	TSIV-2	LTD “SamLit”, Russia	up to 98,6	2000	D= 5000 L=15200,	128	—	allowable gas content - 160 g/m^3	UDAS, intermediate hoppers
	TSIV-5	LTD “SamLit”, Russia	up to 98,6	5000	D=10600 L=31000,	620	—	allowable gas content - 160 g/m^3	UDAS, intermediate hoppers
	PTS-5x2PZ	LTD “SamLit”, Russia	up to 98,6	10000	H=5510, L=2330	1928	—	allowable gas content - 160 g/m^3	UDAS, intermediate hoppers
Battery cyclones	BTS-259	LTD “SAEM”, Russia	90	3960…31680	L=1580…4000, H=3500…5160, b=1430…2770	1850…8100	—	allowable gas temperature at the inlet - 400°C	UDAS, intermediate hoppers
	BTS-2	LTD “SAEM”, Russia	95…98	15048…48888	L=2130…3260, H=3910…4410, b=1160…2450	3000…7150	—	allowable gas temperature at the inlet - 400°C	Silos of UDAS
	TSB-254R	LTD Company group “Edvens”, Russia	85…90	20580…65750	L=1816…3220, H=4542…5342, b=1600…2440	3630… 10000	—	allowable gas temperature at the inlet - 400°C	Silos of UDAS
	PBTS2	LLP “KMZ named after Parkhomenko”, Kazakhstan	96…99	15000…180000	L=2300…6100, H=4500…7500, b=2900…3500	3850… 21700	—	Dust moisture - below 6 %	Silos of UDAS
	BTS-512	LTD NTK “ZENIT”, Russia	92…94	44460…400320	L=4180…8105, H=6970…7480, b=3560…9360	10800… 746000	—	allowable gas temperature at the inlet - 400°C	Silos of UDAS
Fabric	FRTSI-30P(LJI)	JSC “FINGO”, Russia	98…99	3600	H=4650, L=2300, b=16980	1800	—	dust concentration - below 300 mg/m^3	Silos of UDAS
	FRKN	LTD PKF “Story-Service”, Russia	99	510…36720	H=2650...5070, L=1320…5530, b=965…3770	7620	—	hydraulic resistance - below 1800 Pa	Silos of UDAS

Continuation of Table 4

Type	Mark	Manufacturer	Efficiency, %	Performance, m³/h	Dimensions, m,	Weight, kg	Water consumption	Restrictions on use	Field of application of devices at TPPs
Fabric	CRF15	LTD "Diamant", Russia	99,9	15000…90000	H=6100, L=1300…7800, b=2400	1500… 13000	—	dust concentration - below 500 mg/m^3	Silos of UDAS
	FRI	JSC "FINGO", Russia	98…99	58176…155140	H=9325, L=4520…11220, b=4220	15030… 33140	—	allowable gas temperature at the inlet - 200°C	Silos of UDAS
Grain	FZGI	LTD "IMPEK", Russia	98…99	1200…5000	H=2600…4100, L=900…1700, b=900…1700	600…2000	—	allowable gas temperature at the inlet - 300°C	In plants of all types
	DMC	Lipu Heavy Industry Company Ltd., China	99,99	1500…10500	H=2500…3500, D=1000…2000	1000… 4000	—	allowable gas temperature at the inlet - 250°C	In plants of all types
	ZFRM	LTD IPG "Aqua-Venture", Russia	99	30000	H=4000, L=2000, b=2000	3200	—	allowable gas temperature at the inlet - 300°C	In plants of all types
	RZF	LTD NPP "GAZ-ENERGOSTROM", Russia	100	10000…300000	H=8200, L=11200, b=7840	165000… 200000	—	allowable gas temperature at the inlet - 1000°C	In plants of all types
Cassette	SRF-K-VENT-KIANA	LTD "Ecofilter", Russia	99	2000…8000	H=4000…4900, L=1400, b=1400	500…2000	—	allowable gas temperature at the inlet - 150°C	In plants of all types
	FKI	JSC "Semibratovo firm NIIOGAZ", Russia	80…90	1500…33600	H=1925…4100, L=1430…4200, b=1320…3000	540…4200	—	allowable gas temperature at the inlet - 150°C	UDAS, intermediate hoppers
	SRF-K	LTD "Ecofilter", Russia	99	4000…90000	H=3200…5000, L=1300…7800, b=1300…2400	1000… 12000	—	allowable gas temperature at the inlet - 150°C	UDAS, intermediate hoppers
	KAFR	JSC PSO "Cvetmetecologiya", Russia	90	78000…540000	H=7385…8060, L=5050…23600, b=5080…6000	20768… 116500	—	allowable gas temperature at the inlet - 150°C	In plants of all types
Wet cleaning									
Dropping gas washer	GVPV	JSC "FINGO", Russia	90…95	1700…15120	H=1840…8065, L=605…2080, b=365…2080	74…265	0,33… 8,3 l/s	indoor installation, mass concentration at the inlet - below 30 g/m^3	UDAS, intermediate hoppers
	PVM	JSC "NIIOGAZ", Russia	99	3000…40000	H=3185…4950, L=1315…2900, b=1145…4520	550… 3500	0,45…9 l/m^3	indoor installation, allowable gas temperature at the inlet - 200°C	UDAS, intermediate hoppers
	KMP	LTD Company group "Edvens", Russia	99	7000…140000	H=3350…10060, L=2300…5720, b=1415…4105	1060… 10477	0,5… 1,5 l/m^3	indoor installation	UDAS, intermediate hoppers

Continuation of Table 4

Type	Mark	Manufacturer	Efficiency, %	Performance, m^3/h	Dimensions, m,	Weight, kg	Water consumption	Restrictions on use	Field of application of devices at TPPs
Film cyclones	CVP	"Alumotek", Russia	98…99	1250…20000	H=2434…7044, D=315…1000	64…570	0,14… 0,43 l/s	indoor installation	UDAS, intermediate hoppers
	MPR	LTD "UralAktiv", Russia	97	1200…125000	H=4200…10500, L=1400…3350, b=1400…3300	1500… 6000	0,007… 0,027 l/m^3	indoor installation	UDAS, intermediate hoppers
	MP-VTI	Koltansky factory KVOiT, Russia	86…99	64800…137520	H=7960…11160, D=2300…3300	5000… 68000	2,9… 4,1 l/s	indoor installation, allowable gas temperature at the inlet - 200°C	UDAS, intermediate hoppers
	SIOT (OV-02-99 series, extension 6)	LTD "UZGA", Russia	95	2550…210000	H=1440…8980, L=835…6375, b=720…5525	84…1219	0,78 l/s	indoor installation, mass concentration at the inlet - below 5 g/m^3	UDAS, intermediate hoppers
Bubble	Vortex scrubber	LTD Company group "Edvens", Russia	80…90	1500…62245	H=1340…5758, D=400…2000	100…2200	0,2… 0,6 l/m^3	indoor installation	UDAS, intermediate hoppers
	SVA	PIK "Ilmatika", Russia	80…90	500…55000	H=540…4700, D=240…2480	20…1870	0,2…0,3 l/m^3	indoor installation	UDAS, intermediate hoppers
Foam	PASS	JSC "Giprogazoochistka", Russia	95…99	2100…60000	H=2600…6740, D=560…2000	639…4807	0,2…0,3 l/m^3	indoor installation, allowable gas temperature at the inlet - 400°C	UDAS, intermediate hoppers
	PGS-LTI	JSC "Giprogazoochistka", Russia	95…99	2400…52000	H=3200…6100, D=500…2150	494…810	0,8…0,9 l/m^3	indoor installation, allowable gas temperature at the inlet - 400°C	UDAS, intermediate hoppers
	PGP-LTI	JSC "Giprogazoochistka", Russia	95…99	2400…52000	H=3200…6100, D=500…2150	494…810	0,8…0,9 l/m^3	indoor installation, allowable gas temperature at the inlet - 400°C	UDAS, intermediate hoppers
Electrostatic precipitation									
ESPs	EV	JSC "FINGO", Russia	98	74500…348000	H=20150…21700, L=5300…7500, b=6880…19450	27137… 115055	—	allowable gas temperature at the inlet - 250°C	Silos of UDAS
	UG	LTD "KaZBeG", Russia	98…99,8	36000…954000	H=12300…21800, L=9600…24800, b=3000…27000	42800… 896000	—	allowable gas temperature at the inlet - 250°C	Silos of UDAS
	EGA	JSC "FINGO", Russia	97…99	57600… 1026000	H=4890…13990, L=9260…22740, b=12400…19900	38900… 387700	—	allowable gas temperature at the inlet - 400°C	Silos of UDAS
	EGB	JSC "NIIOGAZ", Russia	97…99	57600… 1026000	H=19900, L=22740, b=29540	38900… 387700	—	allowable gas temperature at the inlet - 400°C	Silos of UDAS
	EGD	JSC "Kondor-Eko", Russia	97…99	650000… 2000000	H=3940…3948, L=19060…31105, b=22300…25940	267937… 844897	—	allowable gas temperature at the inlet - 160°C	Silos of UDAS
	EGBM	JSC "Production and Engineering Company "OKA", Russia	97…99	50000… 1300000	H=10410…19910, L=13440…22740, b=4840…25940	38000… 389000	—	allowable gas temperature at the inlet - 300°C	Silos of UDAS

Continuation of Table 4

Type	Mark	Manufacturer	Efficiency, %	Performance, m^3/h	Dimensions, m,	Weight, kg	Water consumption	Restrictions on use	Field of application of devices at TPPs
ESPs	EGV	JSC “NIIOGAZ”, Russia	97…99	36000… 1360000	H=10900-19900, L=9600-48600, b=5540-35700	38000… 399500	—	allowable gas temperature at the inlet - 400°C	Silos of UDAS
	EGAV	JSC “Production and Engineering Company “OKA”, Russia	97…99	50000… 1500000	H=11400-21600, L=8660-34440, b=4600-37400	38900… 399560	—	allowable gas temperature at the inlet - 300°C	Silos of UDAS
	EGT	JSC “Kondor-Eko”, Russia	98…99,9	43200…172800	H=16820-17835, L=12600-16600, b=4970-14020	29295… 144208	—	allowable gas temperature at the inlet - 425°C	Silos of UDAS
	EGSE	JSC “Production and Engineering Company “OKA”, Russia	97…99	50000…2100000	H=11400-21600, L=8660-34440, b=4600-37400	39000… 405000	—	allowable gas temperature at the inlet - 300°C	Silos of UDAS