Parametric restrictions on industrial cleanliness of technological equipment in mechanical engineering

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Abstract. In the presented work, the author has carried out a parametric analysis of technical requirements and restrictions on the use of technological equipment in heavy engineering in clean rooms. The analysis shows the presence of design requirements, manufacturing and assembly requirements, as well as requirements for the maintenance and repair of technological equipment during operation and further, throughout the entire life cycle. A feature of the work is the consideration of previously developed technological equipment and its application in the conditions of modern requirements of clean rooms. Due to the absence of strict requirements in the manufacture of technological equipment, the result of the work performed is the classification of contaminants identified by the author and possible practical recommendations for compliance with the requirements and restrictions of clean rooms of the equipment in operation.

1. Introduction
The analysis of the compliance of the technological equipment previously developed, manufactured and proposed for use in cleanrooms with the requirements for compliance with industrial cleanliness showed that this equipment in many parameters does not meet the existing requirements for ensuring industrial cleanliness.

Various technological equipment will be considered: from special automotive equipment to auxiliary equipment [1].

It should be noted that the structure contains:

- stagnant zones, pockets, cavities hard to clean;
- crevices, gaps, corrugated surfaces that contribute to the accumulation of dust;
- welds, which are mostly made with an intermittent seam, which is a dust concentrator;
- there are no protective devices on the moving parts of the lifting or transport equipment against the ingress of oils and other contaminants in the room.

The materials, components, coatings used in the manufacture of technological equipment also do not meet in most cases the requirements imposed on them in terms of emitted and accumulated contaminants, for example, porous or fibrous (flexible polyurethane foam, felt, fabric fleecy materials, etc. etc.) materials, etc. [2;3].

Thus, the creation of equipment that meets the requirements of industrial cleanliness is a complex problem and is supported by a set of measures carried out at all stages of equipment creation - from design to operation.
2. Requirements and restrictions

2.1. Requirements for the design of technological equipment for clean rooms

The documentation for equipment intended for use in a clean room, minimally sensitive to contamination, excluding, if possible, the causes of contamination, should contain a sufficient amount of necessary additional requirements, means and measures to ensure the design, manufacture and operation of the equipment.

The documents for the equipment must indicate the surfaces and cavities (if any) that are most important from the point of view of ensuring cleanliness during manufacture, storage, transportation and operation, as well as ways of protecting them from contamination and the permissible level of contamination. [four]

The documentation should take into account the possibility of access for maintenance personnel to carry out preventive maintenance and the possibility of access to cleaning sites without the use of additional equipment.

In the construction of consoles, boards, etc. recommended:

- the output of the elements on the panel is made through the sealing gaskets;
- close the front panel with a hinged cover;
- install panels and skins on the body through seals;
- design element handles smooth;
- during manufacture, test the panels for tightness.

The developed electrical equipment must reflect the following requirements:

a) the electrical wiring of the lighting and power circuits of the equipment must be laid hidden with seals at the exit;

b) the placement of luminaires should take into account the requirements for illumination of workplaces and ease of maintenance, including dedusting by regular means.

2.2. Requirements for the manufacture, assembly, storage and transportation of technological equipment

When manufacturing equipment, one must:

- in order to prevent the emergence of sources of contamination and their elimination, the methods and means of processing and forming products, their surfaces and cavities should maximally exclude the formation of scales, flash, chips, burrs and other dangerous contaminants;
- when bending pipelines, do not use fillers made of bulk materials (sand, etc.).

When assembling equipment, one must:

- assembly of equipment at the manufacturing plant to carry out in clean production rooms in compliance with the rules of industrial hygiene according to the manufacturer’s instructions;
- to provide input control of parts and assembly units arriving for assembly;
- parts should not have scales, burrs, chips, burrs, grease stains and other dangerous contaminants on surfaces and in cavities;
- parts and assemblies made of ferrous metals must have a durable metal or paint coating.

Before installing purchased products and accessories, their outer surfaces must be thoroughly wiped with a clean, lint-free cloth soaked in solvent. The surfaces must be “clean in appearance”.

Quality control of cleaning before installing components should be:
• visual (surfaces should not be contaminated);
• by wiping the surface with a clean coarse calico napkin soaked in solvent, - the napkin should not have traces of dust and grease (control is carried out selectively).

For assembly and adjustment of equipment, only the provided technological equipment and tools should be used.

Moving parts of the equipment must undergo preliminary running-in and running-in, followed by cleaning in order to avoid the release of contaminants and lubricants during operation.

Testing and acceptance of equipment at the manufacturer's plant must be carried out in specially prepared production facilities in compliance with the rules of industrial hygiene according to the manufacturer's instructions. Tests of transport equipment should include checks for maneuverability [5].

When packing equipment, one must:
• before packing, all external surfaces must be thoroughly wiped with clean, lint-free wipes soaked in a solvent, followed by rinsing with water until the contamination is completely removed, hard-to-reach surfaces of the equipment should be additionally blown with air or cleaned with a vacuum cleaner.

The cleaned surfaces should be free of dirt, whitish stains, cloth lint, water drops.

The quality control of cleaning before packaging should be:
• visual (surfaces should not be contaminated);
• by wiping the surface with a clean coarse calico napkin soaked in a solvent - there should be no traces of dust and grease on the napkin (control is carried out selectively).

It is allowed to clean the equipment and control the quality of cleaning according to the manufacturer's instructions [6].

When transporting equipment, one must:
• equipment for clean rooms should be transported in closed clean wagons. It is allowed, depending on the dimensions, to use packing cases;
• for large-sized equipment, the use of special containers may be economically impractical, and transportation in closed wagons is impossible due to the size of the equipment - in these cases, the issue of storage and transportation is individual, depending on the type of equipment.

Possible measures to ensure cleanliness during the transportation of such equipment:
• protective covers;
• tight overlap with waterproof wrapping paper, etc.

2.3. Requirements for the selection of materials and coatings
Parts, assembly units for a cleanroom must be made of materials that meet the following requirements:
• should not be a source of pollution of the premises;
• be chemically neutral, resistant to wet cleaning;
• have a high resistance to corrosion;
• have a low surface electrical resistance in order to reduce the electrostatic adhesion of particles;
• oils, greases, sealants must be low-evaporating.
It is not recommended to use materials impregnated with plasticizers or containing polymers with weak polymer bonds between molecular chains (for example, dioctyl phthalate, etc.).

The following non-metallic materials are not recommended:

- porous;
- fibrous (felt, fabric fleecy materials, etc.).

To protect surfaces subject to corrosion, protective metal and paint coatings must be used.

Paints and varnishes should be light colours, lightfast, smooth, have good adhesion, moisture resistant, allowing for wet mechanized and dry cleaning of surfaces. It is recommended to use epoxy enamels as paints and varnishes.

For the production of documentation used in clean rooms, lint-free paper is recommended.

2.4. Requirements for operation, repair and installation

When installing technological equipment, free access must be provided for cleaning its surfaces.

The equipment may be moved across the floor of the cleanroom only on specially provided rollers or trolleys that do not damage the floor covering.

In order to avoid violations of floor coverings when installing large-sized equipment, it is possible to use fluoroplastic products.

The supply of equipment or its components for assembly in a clean room should be carried out from a specially prepared pre-clean room after unpacking and preparation.

The types of preparation operations, equipment and tools, consumables are selected individually, depending on the type of equipment.

Surface cleaning with alkaline agents should be carried out before installing it in a clean room in compliance with safety requirements.

Cranes and lifting equipment used to lift cleaned equipment should be equipped with an umbrella trap attached directly under the hook to collect falling particles, drops of lubricants, etc.

When installing and operating the equipment in a clean room, preservative lubricants are not allowed.

The premises are not allowed to carry out work related to the formation of chips, dust, etc.

Repair of technological equipment should be carried out by replacing components, preferably outdoors.

After installing the equipment in a clean room, the prepared and cleaned equipment should be covered with polyethylene covers. Before starting work, the covers must be wiped with wet, lint-free wipes, and then the covers must be removed.

2.5. Requirements for ensuring cleanliness during equipment operation

During operation, external surfaces must be periodically cleaned.

It is recommended to carry out the following types of surface cleaning: routine (after a certain period of time: week, month, etc.) or current (daily).

During routine cleaning, the surfaces are wet wiped with detergents and vacuum dusting with a vacuum cleaner. Recommended for routine cleaning.

Current cleaning involves damp wiping of surfaces with wipes moistened with distilled water.

The need for current cleaning is checked by selective inspection of surfaces: by wiping the surface with a clean coarse calico napkin soaked in a solvent - the napkin should be free of traces of dust and grease.

The frequency of cleaning depends on the technological cycle carried out using the equipment.

The operating organization performs work to ensure the cleanliness of the equipment.

Personnel should be aware that equipment cleaning is carried out to reduce the amount of dust, moisture, etc. particles deposited by gravity, electrical charges and molecular forces on surfaces.
3. Conclusions
With these requirements in mind and in order to comply with them, it can be determined that preventive action may be the best practice for removing contamination. For example, removing, if present, metal shavings and other contamination from grooves and recesses with a vacuum cleaner and brushes.
Flushing surfaces contaminated with oil or grease with a coarse cloth soaked in solvent. When flushing, pay special attention to thoroughly cleaning the undercut and threaded surfaces of the parts.
The quality control of cleaning after washing should be carried out as follows:

- visual;
- by wiping the surface with a clean coarse calico napkin.

After flushing the structural elements, all surfaces of the structures must be flushed again.
Check visually.
The washed surfaces should be free of dirt, whitish drops indicating poor cleaning, lint of fabric and pieces of foam rubber.
Wipe all washed surfaces with hemmed cambric napkins moistened with distilled water.
Moisten the napkins by sprinkling them with distilled water from containers.
Turn the napkins as they become dirty, then replace them with new ones.
Inspection - visually, the washed surfaces must be clean and free of contamination visible to the naked eye.

In the case of storing cleaned structures, assembly units, parts before assembly in a clean room, cover with covers made of plastic wrap or simply with wrap. Rinse the film surfaces in contact with the cleaned surfaces of the equipment with napkins, and then with clean napkins moistened with distilled water, and then air dry for at least 20 minutes in the preparation room.
For a more accurate result, a parametric decomposition [9] of pollution degrees was carried out and classified as follows:
  a) strong - the presence of preservative lubricants, oils, hard-to-reach contaminants;
  b) medium - the presence of thin layers of mineral oils;
  c) small - local surface contamination.
To avoid contamination of the cleanroom air environment, solvents should be stored in hermetically sealed containers.

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