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Application of Integrated Supports for Electromechanical Pipelines in Factory-Building Projects

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Abstract: In the construction system of modern factory-building projects, the electromechanical-pipeline system serves as core infrastructure guaranteeing factory production operation, equipment maintenance and environmental regulation. The rationality of pipeline layout and the stability of support installation affect the construction quality, operational safety and later-stage operation-and-maintenance efficiency of factory electromechanical engineering. Relying on the technical advantages of standardized design, modular assembly and digital optimization, integrated supports for electromechanical pipelines integrate laying requirements of multi-specialty pipelines and realize orderly, systematic and safe layout of electromechanical pipelines in factory buildings. Combined with the actual construction of factory-building projects, this paper systematically elaborates the technical advantages of integrated supports for electromechanical pipelines, sorts out key processes for on-site standardized construction, and conducts an in-depth analysis of on-site application practices of integrated supports, focusing on dimensions including preliminary design, BIM-technology application, and seismic-system construction. It targets and solves industrial pain points in factory electromechanical-pipeline construction such as collision interference, non-standard installation and poor stability. It provides practical references for standardized and refined construction of integrated supports for electromechanical pipelines in industrial factory buildings, and helps achieve quality improvement, efficiency increase, and safe delivery of factory electromechanical engineering.

Keywords: Factory-building project; Electromechanical pipeline; Integrated support; BIM technology; Construction technology

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1. Technical advantages of integrated supports for electromechanical pipelines

1.1. High space utilization and orderly layout

Electromechanical pipelines inside modern factory buildings cover multiple professional systems. Pipelines vary in pipe diameter, laying route and installation elevation. The traditional scattered-support installation mode causes independent occupation of space and disordered layout of pipelines of various specialties [1]. After adopting the construction mode of integrated supports for electromechanical pipelines, constructors can conduct unified overall planning, layered planning and centralized layout for all electromechanical pipelines in

the factory building. Combined with the factory-building floor height, the position of beam-column structures, and the boundary conditions for equipment installation, support levels and pipeline-layout areas are reasonably divided. Layout is optimized by strictly following basic principles for pipeline arrangement, so as to avoid problems such as pipeline overlapping and crossing, disorderly piled-up supports and waste of space resources in traditional construction. In addition, integrated supports adopt standardized section-steel components with concise and neat overall structures. Multi-layer pipelines can be laid in an orderly layered manner, and pipeline spacing and inter-layer spacing can be controlled in a standardized way [2]. Constructors can accurately plan and reserve sufficient pipeline-maintenance space, equipment-operation space and factory-building passage space, effectively improving neatness and space-utilization rate inside factory buildings and satisfying intensive and standardized construction demands of modern factory buildings.

1.2. High structural stability and excellent safety performance

Integrated supports for electromechanical pipelines adopt factory-based standardized prefabrication mode. Manufacturers uniformly process section-steel components, connecting pieces and anchoring fittings in accordance with national codes and design requirements. Dimensional precision, material strength and hot-dip-galvanizing anti-corrosion performance of components can be precisely controlled. Strict tests on bearing capacity, tensile resistance and corrosion resistance are carried out before components leave the factory. The overall quality stability of components is far higher than that of field-welded supports [3]. During installation of integrated supports, constructors fix supports by anchoring them to high-strength structural members such as factory-building structural beams and columns. The overall stress system of supports is uniform and reasonable, which effectively disperses load pressure of various pipelines and avoids partial overload. Meanwhile, integrated supports can be laid in an integrated manner together with seismic supports, effectively resisting external forces such as vibration from factory-equipment operation, ambient wind pressure and seismic load, improving the overall stability of electromechanical-pipeline systems, and guaranteeing long-term safe and stable operation of factory electromechanical systems from the structural perspective.

1.3. Improved construction efficiency and effective construction-schedule control

Traditional construction of supports for electromechanical pipelines requires multiple on-site procedures including cutting, welding, grinding and anti-corrosion painting. The construction procedures are cumbersome, with long operation cycles. Moreover, on-site welding produces open fire, smoke and waste residues, which not only pollute the construction-site environment but also bring certain fire-safety hazards. Construction quality and progress can hardly be precisely controlled. In view of the above problems, integrated supports for electromechanical pipelines adopt a modular assembly-type construction mode without secondary welding or secondary processing on-site [4]. Constructors only need to complete simple procedures including surveying-and-setting-out, base anchoring, component assembly and bolt tightening according to construction drawings to finish support installation. On-site construction procedures are simplified and overall construction efficiency is improved. Furthermore, the standardized and modular construction mode of integrated supports effectively avoids on-site rework and reduces rework-and-rectification workload caused by layout conflicts, dimensional deviations, and unqualified quality.

2. Key on-site construction processes for integrated supports

2.1. Accurate surveying-and-setting-out and base-anchoring construction

Surveying-and-setting-out constitutes a core procedure for installation of integrated supports. Constructors shall carry out accurate setting-out operations based on final construction drawings optimized by BIM technology, combined with construction datum lines and elevation control lines of factory-building civil-engineering structures. Constructors shall check basic parameters in advance, including dimensions of factory-building beam-column structures, floor-slab thickness, and wall positions, to prevent structural deviations from affecting the installation precision of supports. On structural surface layers of the factory building, accurately mark installation points of each support suspender, installation elevation of cross-arms and overall installation spacing of supports. All marked points must be clear, accurate and unified, and setting-out precision shall be kept within allowable deviation ranges specified in codes [5].

Base anchoring serves as a key procedure guaranteeing anchoring stability of integrated supports. Constructors shall strictly follow the construction principle of "giving priority to anchoring onto structural members and avoiding weak zones". High-strength structural parts such as factory-building concrete beams, columns and load-bearing walls shall be selected as anchoring points for supports. Drilling and anchoring are strictly prohibited in regions with insufficient bearing capacity such as weak floor slabs, infill walls and decorative surface layers of the factory building. Before drilling, constructors shall adopt professional detection instruments to check the positions of internal steel bars and pre-embedded pipelines in drilling areas, so as to prevent drilling operations from damaging original factory-building structures and pre-embedded facilities. After drilling, dust and sundries inside holes shall be cleaned before special anchoring bolts are installed.

2.2. Standardized support assembly and precision-verification construction

Constructors shall strictly follow the assembly sequence of "main members first, secondary members afterwards; vertical members first, horizontal members afterwards; overall structure first, partial components afterwards", and successively complete full-set procedures including suspender installation, vertical-brace fixation, cross-arm splicing and connecting-piece tightening. Install suspenders vertically according to setting-out points and ensure that suspender verticality meets code requirements. The top ends of suspenders shall closely fit anchoring bases without loosening or offset [6]. After suspender installation is finished, assemble vertical-brace components and horizontal cross-arms in sequence. All splicing positions of components shall fit closely and align flatly without gaps, dislocation, deformation or other quality defects.

For integrated supports with multi-layer pipelines, constructors shall strictly control inter-layer spacing of supports of each layer in accordance with design drawings, and reserve sufficient space for pipeline laying, later-stage maintenance-and-operation and equipment heat dissipation, so as to guarantee smooth follow-up pipeline construction and operation-and-maintenance work. After overall assembly of supports is completed, constructors shall conduct comprehensive verification of the overall flatness, verticality, and levelness of supports, and timely adjust and correct deviated parts [7]. In addition, constructors shall re-inspect the overall mechanical performance of supports. Only after confirming that bearing capacity, stability and installation precision of supports all satisfy design and code requirements can follow-up laying of electromechanical pipelines be carried out.

2.3. On-site finished-product protection and anti-corrosion protection construction

Components of integrated supports are all treated by hot-dip-galvanizing anti-corrosion processes. The

galvanized layer on component surfaces acts as a core protective layer against corrosion and guarantees the service life of supports. Finished-product protection must be well implemented throughout construction. During component transportation, stacking and assembly, constructors shall handle components with care. Throwing or dragging components at will is forbidden to avoid bump damage, scratches, or peeling off of galvanized layers on component surfaces.

Targeting the special production environment of energy-storage factory buildings characterized by high humidity, heavy dust and frequent equipment vibration, constructors shall carry out special sealing-protection treatment for weak positions such as support connecting joints, drilled anchoring points and component splicing gaps. Special sealant and anti-corrosion coatings are adopted to seal joint gaps so as to isolate erosion by moisture and dust and prevent rusting and aging of these positions. During cross-operations such as pipeline welding and equipment installation, supports shall be shielded and protected to avoid damage to support components and anti-corrosion layers caused by welding slag, high temperature and mechanical collision. The durability and environmental adaptability of integrated supports are comprehensively improved.

3. Application practices of integrated supports for electromechanical pipelines in factory-building projects

3.1. Preliminary drawing integration and support-scheme planning

In the preliminary project-construction stage, construction organizations shall arrange professional technicians to comprehensively sort out complete civil-engineering and electromechanical construction drawings of factory buildings, and systematically integrate pipeline-design parameters of all specialties including water-supply-and-drainage, ventilation-and-air-conditioning, electric power, fire-protection sprinkler, weak-current intelligence and process pipelines [8].

First, technicians shall check core data item by item, including pipe-diameter dimensions, pipe material, laying routes, design elevations, bearing loads, and equipment-connection positions of various pipelines, and accurately grasp overall layout demands of factory-building electromechanical systems. Meanwhile, combined with on-site conditions such as actual factory-building floor height, layout of beam-column structures, dimensions of equipment foundations, positions of wall openings and arrangement of production equipment, technicians shall comprehensively investigate restricted zones and available zones for pipeline laying, and accurately delimit the overall laying scope of integrated supports.

Second, technicians shall strictly follow core layout principles for electromechanical pipelines in industrial factory buildings: “small-diameter pipelines give way to large-diameter ones; weak-current pipelines give way to strong-current ones; atmospheric-pressure pipelines give way to pressure-bearing ones; priority for convenient maintenance; low-temperature pipelines give way to high-temperature ones”. Combined with importance, operation-and-maintenance frequency and construction difficulty of pipelines of various specialties, technicians shall preliminarily plan hierarchical structures, installation spacing, section-steel specifications, anchoring points and layout schemes of integrated supports. Special scheme planning shall be conducted for key zones such as large-space pipe galleries, equipment machine rooms, dense-pipeline zones in interlayers and pipeline zones in fire-protection passages. Support-layout density shall be reasonably increased and hierarchical layout of supports shall be optimized to guarantee stability and neatness for laying of dense pipelines.

Third, technicians shall optimize scheme design in combination with production-process characteristics

of factory buildings. Energy-storage factory buildings contain a large number of electrical equipment, energy-storage modules and ventilation-and-dust-removal equipment. Pipeline laying shall take equipment-operation safety, heat-dissipation requirements and convenient operation-and-maintenance into account. During support planning, equipment heat-dissipation zones, operation-working surfaces and maintenance passages shall be avoided to guarantee normal operation of production equipment and smooth progress of later-stage operation-and-maintenance work.

3.2. BIM three-dimensional modeling optimization and collision-detection application

First, leverage the collision-detection function of BIM models to conduct all-round collision inspection of factory-wide pipelines, supports and civil-engineering structures, and accurately identify problems such as crossing conflicts and overlapping interferences among pipeline-to-pipeline, pipeline-to-support, pipeline-to-civil-engineering beam-column and pipeline-to-equipment [9]. Technicians shall analyze causes for each collision point one by one, and formulate targeted optimization-and-adjustment schemes combined with pipeline functions, construction codes and operation-and-maintenance demands. Priority shall be given to adjusting routes, elevations and layout positions of secondary pipelines while keeping original layout schemes of main pipelines and core process pipelines unchanged. Optimal layout of all pipelines and supports can be realized on the premise of satisfying code requirements.

Second, targeting difficult-construction zones such as large-height spaces, dense pipe galleries, equipment machine rooms and interlayers of factory buildings, technicians shall upgrade BIM-model precision to LOD400 fine-detail level. Carry out fine-simulation layout for support-component dimensions, installation spacing, hierarchical layout and anchoring points, and accurately restore on-site installation effects. Relying on BIM models, complete support-quantity-of-work statistics, summary of component specifications and positioning of construction points. It provides accurate data support for component prefabrication, material procurement and on-site construction disclosure, and solves problems of empirical-based and blind on-site construction.

In addition, technicians can carry out visual construction disclosure based on BIM models. Optimized support-layout schemes, pipeline-laying routes, and key and difficult construction points are intuitively presented to constructors. Constructors can clearly understand construction standards and installation requirements, which reduces construction deviations, cuts down on-site rework and rectification, and improves precision and standardization of on-site construction of integrated supports.

3.3. Integrated layout of integrated supports and seismic systems

Electromechanical-pipeline systems of factory buildings are prone to shaking, deformation and falling-off under the influence of earthquakes, equipment vibration and wind-pressure loads, which directly affects factory-production safety and overall seismic performance of buildings [10]. Therefore, technicians shall accurately calculate seismic loads of pipelines according to pipe-diameter dimensions, laying lengths and material types of factory-building air ducts, water-supply-and-drainage pipelines, cable trays and process pipelines, and reasonably plan layout spacing and installation positions of longitudinal seismic supports and lateral seismic supports. For example, evenly arrange seismic supports on straight sections of various pipelines in accordance with code requirements, and increase seismic-point density at pipeline bends, end positions and equipment-connection positions to effectively resist damage to pipeline systems caused by horizontal seismic forces and vertical vibration loads.

During on-site installation, constructors shall assemble seismic supports strictly in accordance with BIM-optimized seismic schemes, and guarantee that installation angles, spacing and tightening strength of seismic diagonal braces, suspenders and connecting pieces comply with code requirements. Ensure that seismic supports can effectively restrain pipeline displacement and offset vibration loads. For high-risk points such as long-span pipelines, high-altitude-laid pipelines, and pipelines connected with heavy-duty equipment, carry out special seismic checking and calculations in advance and add reinforced seismic supports to improve the seismic-protection capacity of special points.

To sum up, the integrated load-bearing and seismic-support system enables factory-building electromechanical pipelines and building structures to form a stable integral structure. It not only meets daily load-bearing and fixing requirements for pipelines, but also effectively improves the capacity of electromechanical systems to resist earthquakes, equipment vibration and wind-pressure impact. It minimizes risks of electromechanical-pipeline damage caused by external loads and guarantees safe and stable operation of factory-building electromechanical systems under both normal and emergency working conditions.

4. Conclusion

With core advantages of neat layout, high stability, high-efficiency construction and favorable seismic performance, integrated supports for electromechanical pipelines change the scattered-support construction mode for traditional factory-building electromechanical pipelines. They effectively solve industrial pain points of traditional construction, including space waste, disordered layout, numerous quality hazards, and schedule delays. They constitute key technical means for quality improvement, efficiency improvement, and standardized construction of electromechanical engineering in modern industrial factory buildings. The standardized application of integrated supports in factory-building projects relies on refined preliminary planning, BIM-based digital-optimized design, standardized construction technologies and integrated seismic layout to comprehensively guarantee layout neatness, structural stability and system safety of pipelines. In follow-up construction, construction organizations shall continuously optimize design and construction technologies of integrated supports, deepen application of digital technologies, strictly control construction quality of each link, give full play to application values of integrated supports, and provide solid technical guarantee for safe, stable and efficient operation of electromechanical systems in modern factory buildings.

Disclosure statement

The author declares no conflict of interest.

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