High-Power Shortwave Multi-Pattern Rotatable Antenna Post-Maintenance Report

Authors: Zhang Zhao

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Abstract

This paper briefly introduces the basic composition of high-power shortwave multi-mode rotating antennas for radio stations, and based on the practical work of the current major maintenance overhaul of the antenna system, describes aspects including tool usage in maintenance operations, paint selection for coating, and construction methods for reflector screen inspection and repair.

Full Text

Maintenance of High-Power Shortwave Multi-Mode Rotating Antenna

Abstract: This paper briefly introduces the basic composition of a high-power shortwave multi-mode rotating antenna system for radio stations, and describes practical aspects of maintenance work based on a recent major overhaul, including tool selection, paint coating choices, and construction methods for reflector screen inspection and repair.

Keywords: rotating antenna; maintenance; reflector screen inspection

Author: Zhang Zhao

1. Basic Introduction to the Rotating Antenna

A certain station directly under the State Administration of Press, Publication, Radio, Film and Television of China previously imported a 500kW shortwave broadcast transmission system equipped with a rotating antenna. The transmission system comprises two major components: a 500kW shortwave broadcast transmitter with its dummy load, and an antenna system covering the

frequency range of 6–26.1 MHz. The antenna is installed in a back-to-back configuration, consisting of high-frequency and low-frequency two-phase horizontal dipole antennas that can form eight different operating modes—equivalent to eight individual antennas—enabling 360° omnidirectional broadcasting across the entire shortwave band for various distances and directions. The shortwave rotating antenna overcomes numerous limitations of fixed antennas, including narrow frequency bandwidth, fixed directionality, the need for multiple antennas and switching systems to achieve multi-directional broadcasting, large land area requirements, and inflexible operation.

The rotating antenna stands nearly 80 meters high, spans 76 meters in width, and weighs 250 tons. The entire antenna system consists of the foundation, support structure, feed system, mechanical drive system, in-tower RF equipment, antenna control system, power distribution, lighting, air conditioning, lightning rod, and aviation signal lights. All outdoor feed lines use multi-strand copper wire in a balanced configuration, with varying cross-sections for impedance matching and power handling. The reflector screen is constructed from Φ3.0mm copper wire mesh.

2. Main Maintenance Tasks

The major overhaul included the following primary tasks: (1) tightening tower connection bolts; (2) repainting the tower structure; (3) inspecting and repairing the reflector screen; and (4) installing and replacing iron pipes for insulating rods to facilitate maintenance and replacement of damaged components. Safety management protocols were implemented at the construction site, with warning tape erected around a radius equal to the tower height. Safety signs were posted, including “Construction Site, No Unauthorized Entry” and “Safety Helmets Required,” to minimize material loss, safety incidents, and personnel injuries during construction.

3. Maintenance Implementation

3.1 Maintenance Rationale After more than a decade of exposure to wind and rain, particularly under high-altitude wind-induced vibration, previously secured bolts on the rotating antenna often become loose, creating safety hazards for normal operation and routine maintenance inspections.

3.2 Tool Selection A flange with a diameter of 4.3 meters is installed at the top center of the rotating antenna transmission room, with 72 uniformly distributed bolt holes (40mm diameter) secured by 72 high-strength bolts. Additionally, the tower structure, platforms, and diagonal support arms contain over 18,000 bolts. One key maintenance task was tightening all tower bolts. Based on technical specifications, we selected the AC AC1103 preset torque wrench for bolt tightening, featuring preset torque values, an anti-tamper device, and a torque range of 80–300 N · M.

3.3 Maintenance Benefits Tightening all tower connection bolts enhances structural integrity and stability, extends the service life of the tower structure, and establishes a foundation for safe transmission operations.

3.5 Tower Structure Painting

3.5.1 Painting Rationale As the supporting structure for the antenna, the steel tower and its components are fully exposed to the elements. Long-term exposure to air pollution, year-round precipitation, wind, and solar radiation inevitably degrades structural performance. The rotating antenna had not undergone painting or anti-corrosion maintenance for nearly a decade. Inspection revealed that over 90% of the tower surface had lost its coating gloss, and more than 25% exhibited rough, weathered, or cracked surfaces, necessitating immediate painting and anti-corrosion maintenance.

3.5.2 Paint Selection This project utilized Jotun paint from Norway, a brand with over 80 years of history. Based on premium acrylic resin, this coating offers excellent flow properties, UV radiation resistance, marine humidity resistance, acid rain resistance, alkali resistance, mold prevention, and one-way breathability. Selected paint materials are shown in .

Paint Specifications

Component	Specification (L/bucket)	Mixing Ratio (A:B)
Acrylic topcoat (base)	500	-
Epoxy primer 500 Component B	500	-
Epoxy primer 500 Gray A	500	-
Acrylic topcoat orange base A	500	-
Jotun Thinner No. 7	-	As required

3.5.3 Surface Preparation Practical experience demonstrates that most coating defects originate from inadequate surface preparation—no coating can perform optimally on poorly prepared surfaces. Painting over rusted or oily surfaces represents significant waste of time and resources, while high-quality surface preparation substantially extends coating lifespan. Surface preparation involves three aspects:

1. **Structural Treatment:** Addressing the substrate itself, including removal of weld spatter, grinding of sharp edges, filling and smoothing of weld holes, and rounding of corners.
2. **Surface Cleaning:** Removing surface contaminants detrimental to coating adhesion, particularly oxide scale, grease, soluble salts, rust, and moisture.
3. **Surface Roughness:** Appropriate roughness increases coating contact area and provides mechanical interlocking to improve adhesion. However,

excessive roughness can cause insufficient coating thickness at peaks, leading to premature pitting corrosion.

3.5.4 Painting Method The traditional method was employed, with workers ascending the tower and using rollers for painting. Strict attention was paid to coating density, thickness, and uniformity.

3.5.5 Post-Painting Results Following meticulous painting, the tower structure exhibits bright, aesthetically pleasing coloration. The surface now provides UV resistance, humidity resistance, acid rain resistance, alkali resistance, and mold prevention—effectively addressing the impacts of the station's special climate and ecological environment while significantly extending the tower's service life.

4. Reflector Screen Maintenance

The rotating antenna's reflector screen consists of high-frequency and low-frequency sections. The reflector mesh is woven from 3.0mm diameter copper wire as horizontal ribs and 9.0mm diameter copper wire as vertical ribs.

4.1 Binding Material Selection Since installation, the reflector screen nodes have been secured with transparent tape to prevent unraveling. While temporarily effective, transparent tape degrades through weathering and oxidation over time, losing its binding function and causing copper wire joints to loosen or break. Loose or broken wires can cause arcing during broadcasting, creating safety hazards. This maintenance project replaced transparent tape with 3M copper foil tape based on testing results. This copper foil tape offers excellent strength, toughness, conductivity, adhesion, and safety, is convenient for construction, and does not affect any antenna electrical parameters.

4.2 Reflector Screen Maintenance Procedure The following steps describe the high-frequency reflector screen maintenance process:

1. **Safety Tagging:** Before each maintenance operation, the transmitter must be shut down. The antenna safety officer attaches their safety tag to the transmitter antenna control power switch to prevent accidents from accidental switch closure or high-voltage activation.
2. **Equipment Setup:** Workers transport two 1-ton pulleys and a bundle of thin hemp rope to the third platform of the rotating antenna. The small pulleys are secured to the reserved horizontal steel wire rope (18mm diameter) at one end. One end of the hemp rope is threaded through a small pulley and lowered to ground level to pull up a 4-ton main pulley for the work basket.

Ground personnel cooperate with tower workers to prepare the 4-ton main pulley, attaching four appropriately sized shackles to the pulley's lower ring. The

left and right shackles connect to hemp rope ends threaded through 1-ton small pulleys to control horizontal movement of the main pulley along the maintenance steel wire rope. The center shackles connect to wire ropes prepared with appropriate grips and three clamps—one serving as the main lifting rope for the work basket, the other as a safety rope. This safety rope prevents basket falls and casualties in case the main rope breaks.

Once ground preparations are complete, antenna technicians pull the main pulley up via the hemp rope and secure it to the reserved maintenance wire rope. Another 1-ton pulley is hung at the opposite end of the maintenance wire rope, with the second hemp rope threaded through it. The two wire ropes are adjusted to prevent crossing or tangling, completing the tower rigging. Ground personnel connect the assembled work basket to both the main and safety wire ropes, test the lifting mechanism, and prepare for elevated operations if everything functions properly.

3. **Basket Operations:** Two antenna workers ascend in the basket simultaneously to perform high-altitude reflector screen maintenance. Copper foil tape is cut into 1.5cm-wide strips. The basket uses an automatic lift control system, allowing workers to adjust height while ground personnel control horizontal position by pulling the two hemp ropes. Every weaving point between horizontal and vertical ribs, vertical ribs and side arcs, and vertical ribs and top cross members is inspected. Residual transparent tape is removed, and intact nodes are wrapped securely with new copper foil tape. Loose or unraveled wires are re-woven according to design specifications, wrapped with copper foil tape, and spacing between ribs is adjusted.

Conclusion

This major rotating antenna maintenance project addressed identified issues promptly, including tower painting, bolt tightening, and reflector screen repairs, eliminating safety hazards and establishing a solid foundation for future safe broadcasting operations. The project enriched maintenance personnel experience, improved maintenance efficiency, enhanced technical capabilities, and accumulated valuable experience for similar future projects.

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Author Affiliation: Beijing Radio and Television Maintenance Center, State Administration of Press, Publication, Radio, Film and Television of China

Note: Figure translations are in progress. See original paper for figures.