Walker Process Equipment
Division of McNish Corporation

Technical Memorandum

By
Daniel J. Schmitz, P.E.
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The Use of Purlins in Digestion Cover Design

Purlins are structural members that are a common component in digestion covers. They are meridian members that laterally brace the main radial structural members and support the roof plates. They are located at the panel points if the main radial member is a truss. If the main radial member is an arched beam, the purlins are located based on roof plate lengths and l/r (slenderness ratio) properties of the beam. Purlins make the installation of the roof plates easier and add to the structural design strength of the cover. Today, some cover designs being sold have eliminated all, or all but one or two rows of purlins. The elimination of the purlins has probably been done as a cost-reduction measure for the manufacturer but brings into question whether the lighter cover design meets AISC code requirements. Increased installation costs and decreased structural integrity of the cover make this design less desirable.

Installation difficulties occur when purlins are not used. Roof plates sag from their own weight when they are laid across the main radial members. This deflection can be significant, in larger spans exceeding an inch. The next roof plate laid closer to the center of the cover will sag less because it spans a shorter distance as the radial members converge toward each other the closer they get to the cover's center gas dome. This creates a gap between the two plates where they overlap.

With this gap where the two plates overlap, special means must be used to bring the two plates together to do the required welding. Temporary supports, use of a three-point suspension jig, cambering the plates, or some other means must be used to bring the plates together so they can be welded together.

The first two methods add to construction costs of the cover. Cambering the roof plates adds to fabrication cost of the cover. Sometimes, depending on blocking arrangements, the roof plates will take a camber or set on their own while being stored prior to installation. This camber may be beneficial when installing the plates but it will be uncontrolled in magnitude. The lower roof plate, being larger may take a larger set than the smaller roof plate that overlaps it. Some roof plates may have no set. This still leads to a gap between the two plates that will have to be dealt with during welding.

Roof plates that span longer distances flex more and will tend to oil-can more than ones that are supported from underneath with purlins. This creates a greater sense of insecurity and less secure footing for operators and maintenance workers. In addition, residual stresses are created in the welds when the roof plates must be forced together due to gaps. The increased flexing, oil-canning, and the residual weld stresses could potentially over time lead to fatigue cracks in the welds.

When purlins are used, the above problems are minimized or eliminated. The purlins support the edges of the roof plates that overlap. This minimizes the gap between the roof plates at the weld seam and in turn minimizes residual stresses in the welds. The purlins vertically stabilize the roof plate edges so that they are easier to weld together and they don't bounce or move as much during operation and maintenance.

Purlins are also structurally important. They provide lateral bracing for the main radial structural members and distribute live and dead loads to them. For radial trusses, the purlins distribute the loads directly into panel points, the most rigid parts of the truss.

The conical shape of the roof of a digestion cover dictates that the purlins framing into the radial members will resist the tension and compression forces arising from dome action. Purlins nearest the center of the dome will have compressive forces while the purlins near the perimeter of the dome will have tension forces. Uplift from wind or gas loading will reverse the direction of these forces. This dome type of behavior is beneficial in that it reduces the bending forces in the radial member.

Domes that do not have purlins resist the tension and compression forces through shell action with the roof plates resisting the meridian forces. Thin plates can withstand the tensile forces but will have very limited capability in resisting the compressive forces, which tend to buckle the thin plate. A thicker roof plate (or a plate with stiffeners) is required for this type of dome than for a dome with purlins. Good practice would require that the structural design of covers that do not utilize purlins include analysis of these compressive forces in the roof plates. The required additional thickness for the plates or the required size and type of stiffeners to ensure that these covers will support the specified design loads should be determined during the design process.

In summary, purlins are a valuable component in a digestion cover design by facilitating the installation of the roof plates, supporting the roof plates during operation, structurally bracing the main radial members, and adding to the structural integrity of the cover as a whole.

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