



Module Feeder Inspection System for Plastic Contamination: Design Update

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1. Objective

This report describes the updated design and operation of an inspection system that provides ginners an instantaneous view of the dispersing cylinders in a cotton gin module feeder. Images are provided by network IP cameras installed in the back wall of a module feeder using a new adjustable housing design that allows for easier installation into various module feeder designs. We observed that when these systems are installed and operated, accumulation of plastic and other contaminants on dispersing cylinders is detected and removed more quickly than when the cylinders are manually checked between work shifts or during other pauses in gin operation. Gin crews are more responsive to plastic accumulation on the dispersing cylinders because they can see when it occurs and quickly remove the contaminants, thereby reducing the risk of plastic contamination in lint bales. Figure 1 shows an example image captured by an inspection system installed at one commercial-gin testing location in 2020.



Figure 1: Module feeder image capture by inspection system with pink plastic on dispersing cylinders.

2. System Overview

The basic module feeder inspection system consists of a network IP camera, a camera mount assembly and LED lights installed in the back wall of the module feeder dispersing cabinet, and software to view the video stream data from the camera. Multiple cameras can be installed across the width and/or height of the module feeder back wall to enable viewing of the full width/height of the module feeder dispersing cylinders. Network IP cameras can be connected directly to a PC running the viewing software with an ethernet cable or they can be connected to a network switch to allow connection of multiple cameras to a single PC. The cameras are powered from either an external power supply (e.g. 12 vdc wall adapter) or by a power over ethernet (POE) connection which conveniently transfers data and power through the same network cable. LED lights are used to provide supplemental light necessary to view the dispersing cylinders. The software used to view the video data from the network cameras is to be provided by the gin and will often come with the camera from the manufacturer. Alternatively, free-ware software packages available on the internet can be used to view the video stream from most modern network IP cameras. In any case, the simple viewer software displays the live video stream from the network IP camera(s). Thus, the ginner must manually pause the module feeder floor briefly to allow the cotton to fall away from the back of the dispersing cylinders to obtain a clear view of any accumulation of contaminants on the cylinders.

3. Adjustable Camera Mount – Design and Installation Details

The network IP cameras used in the module feeder inspection system are installed into the back wall of the module feeder dispersing cabinet using adjustable mount assemblies (Figure 2 a and b). Each assembly requires a 7 in x 7 in opening to be cut into the back wall of the feeder and 3/16 in diameter holes drilled to mount the hinge at the base of the assembly and the toggle clamps which hold the camera mount in operating position. The mount assemblies provide +/- 30 degrees of elevation adjustment allowing the camera to be positioned more conveniently on the rear wall of the feeder while maintaining the desired view of the dispersing cylinders. Each camera is held in place by a “ball-faced” sleeve made from UHMW plastic that pivots on two steel plates welded to the front face of the mount. A replaceable lens protector made from scratch and impact resistant clear acrylic is installed in front of the camera lens to protect the camera from debris impact in the feeder.

An optional air nozzle is included in the camera mount design to direct compressed air over the face of the lens protector and help clear accumulation of dust and debris. A push-to-connect fitting is used to attach the compressed air supply line to the nozzle so that the air line can be easily disconnected when the assembly is pivoted away from the feeder wall for periodic cleaning and maintenance.

LED lights are installed adjacent to the cameras to provide supplemental light. We observed that a minimum of 2500 lux (232 ft-candle) of illuminance is needed at the dispersing cylinders to produce a clear image. It is important that the lighting coverage is uniform across the back side of the dispersing cylinders to produce clear images that are free from dark areas or regions of low resolution. Installation of the LED light bars used in the module feeder inspection system require a rectangular opening to be cut in the rear wall of the module feeder and housing clamps provided by the manufacturer are used to fix the lights in place. The LED light bars are powered by an external driver that converts 120 VAC to 12 VDC power (one driver per light bar).

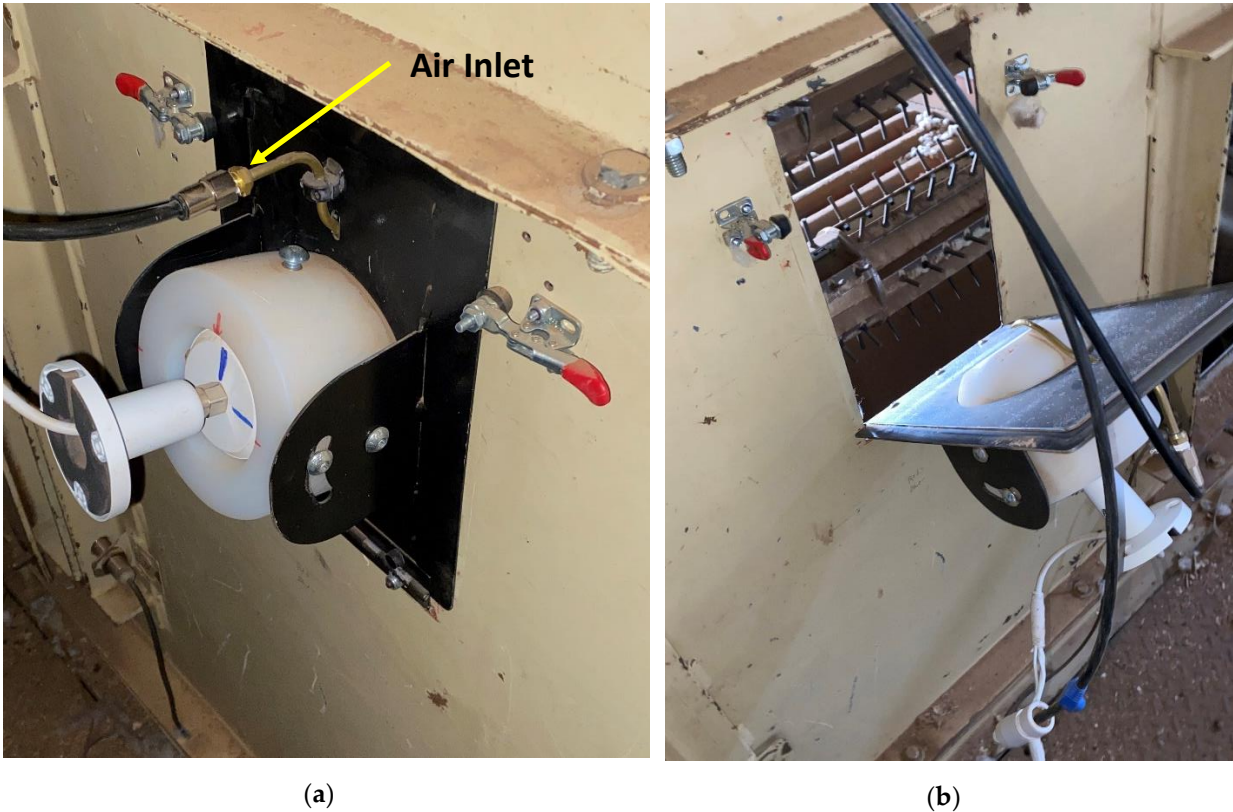


Figure 2. Adjustable mount for network IP camera installed on the back wall of a module feeder. The camera is held to the back side of the module feeder by quick release toggle clamps (figure 2a) and a hinge at the base that allows the camera to be tilted out of operating position for maintenance (figure 2b). Supplemental compressed air is provided through the air inlet (figure 2a) to help clear dust and debris from the lens protector.

A view of the adjustable camera mount from the inside of the module feeder dispersing cabinet is shown in figure 3. The smooth shape and minimal protrusion inside the module feeder back wall of the ball-faced camera sleeve and polished air inlet nozzle provide minimal resistance to cotton moving down the back wall of the feeder. At maximum elevation adjustment (i.e. the camera angle adjusted all the way up or down), the camera sleeve extends approximately 1.15 in inside the back wall of the module feeder. With the camera lens parallel to the feeder back wall, the camera sleeve extends inside 0.76 in.

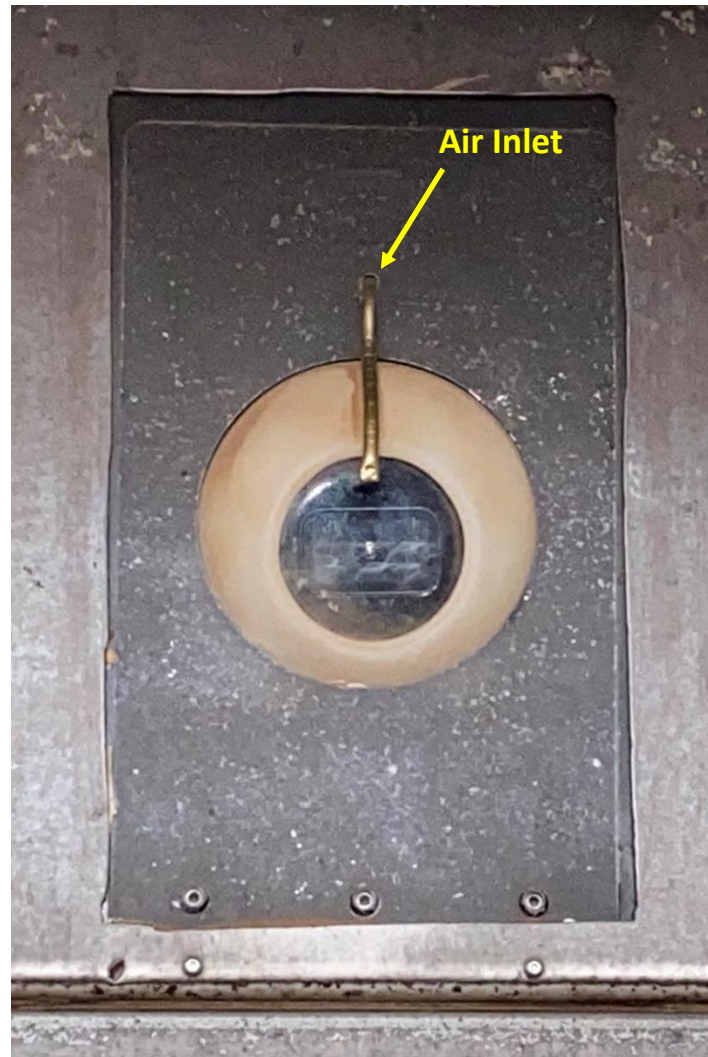


Figure 3. Internal view of the adjustable camera mount installed on the back wall of a module feeder. The smooth shape and minimal protrusion of the camera sleeve and air nozzle provide minimal resistance to cotton moving down the back wall of the feeder.

The cameras and lights should be positioned on the back wall of the module feeder to capture a complete view of the dispersing cylinders. This may require the installation of multiple cameras that provide images that somewhat overlap one another. The camera and light positions are determined based on the distance between the back wall of the feeder and the dispersing cylinders in addition to the slope of the back wall relative to the dispersing cylinders. Best practice is to connect the cameras to the PC and viewing software and manually hold the cameras on the inside back wall of the feeder. The camera position is adjusted until the image coverage is suitable. Two possible camera and light position scenarios are shown in figure 4. The placement scenario shown in figure 4a can be used when there is adequate distance between the back wall and dispersing cylinders to provide complete view of the top and bottom cylinders. The images from the cameras installed as shown in figure 4a will overlap in the center of the dispersing cylinders. The camera and light position schematic shown in figure 4b can be used in situations where the distance between the back wall of the feeder and dispersing cylinders is not adequate to provide a complete image of the top and bottom cylinders. In figure 4b, the top and bottom cameras are spaced vertically to

provide full cylinder length images of the upper and lower dispersing cylinders, respectively. The images from cameras installed as shown in figure 4b will overlap on a portion of one of the middle dispersing cylinders. An example of the vertical camera installation from the outside and inside of the feeder dispersing cabinet at one commercial gin testing location is shown in figure 5 a and b, respectively. Another alternative camera/light location to consider is the roof of the module feeder due to clearance issues. In any case, light placement and illuminance levels are critical to providing clear, bright images that clearly show accumulation of plastic or other contaminants on the dispersing cylinders. Placement of additional lights over those shown in figure 4 may be needed to provide a minimum illuminance value of 2500 lux.

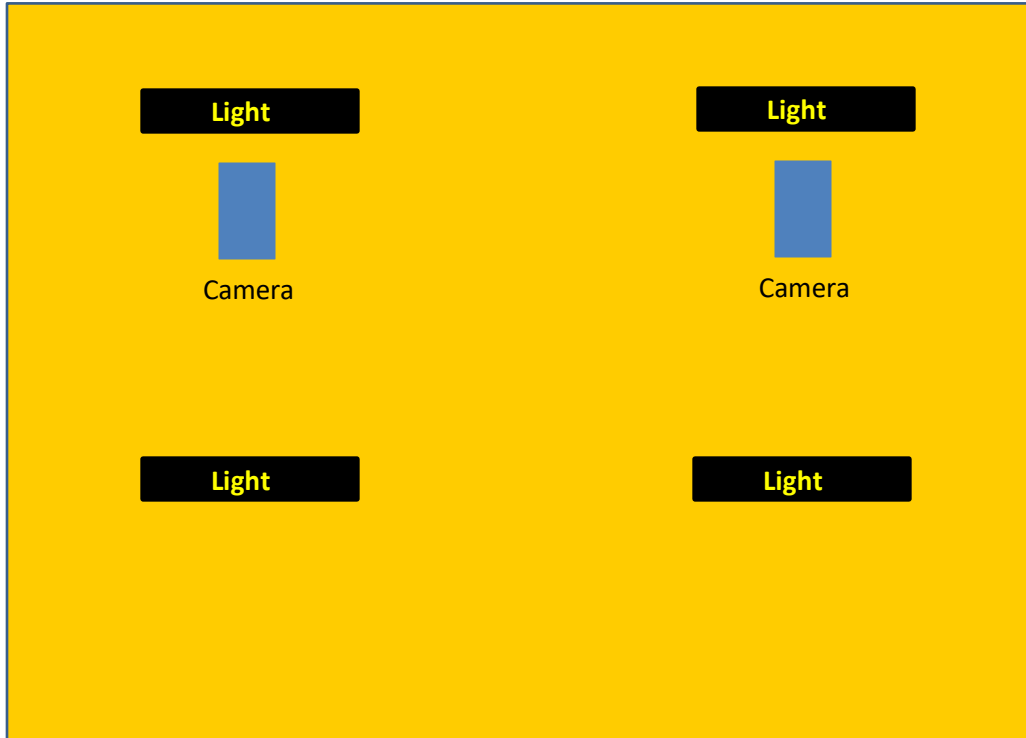


Figure 4a. Placement of camera and light components on the back wall of a module feeder when sufficient distance between the back wall and cylinders exist for the cameras to provide an image of all cylinders from top to bottom. Black boxes indicate placement of lights, blue boxes indicate placement of camera housings.

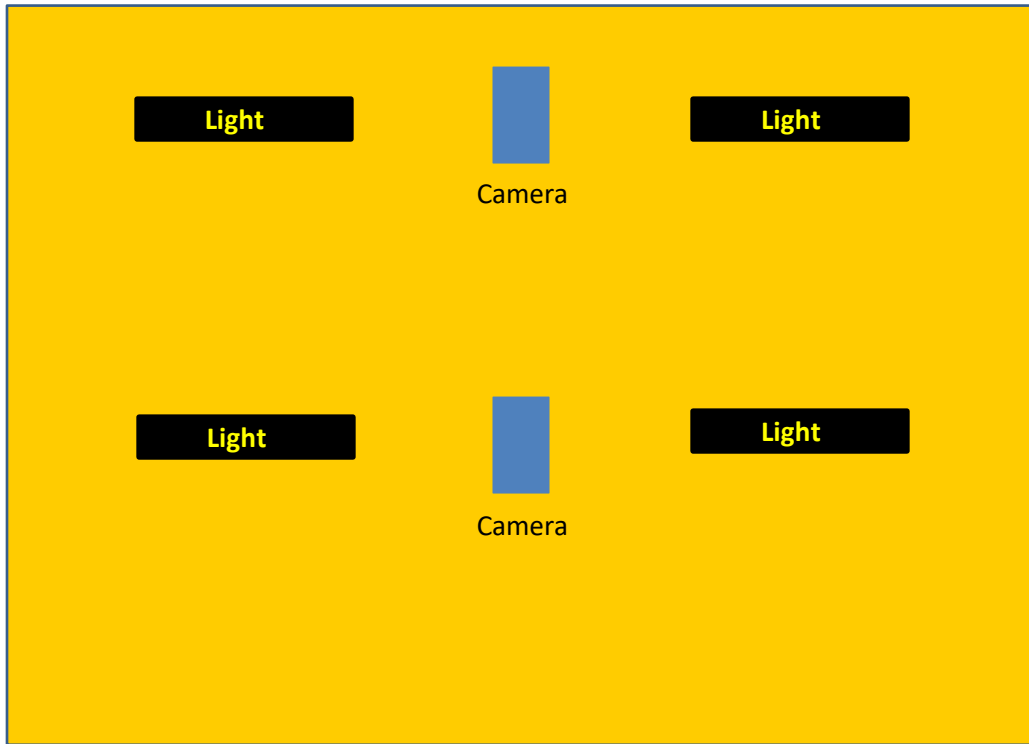


Figure 4b. Placement of camera and light components on the back wall of a module feeder when the distance between the back wall and cylinders is not sufficient for the cameras to provide an image of all cylinders from top to bottom. Black boxes indicate placement of lights, blue boxes indicate placement of camera housings.

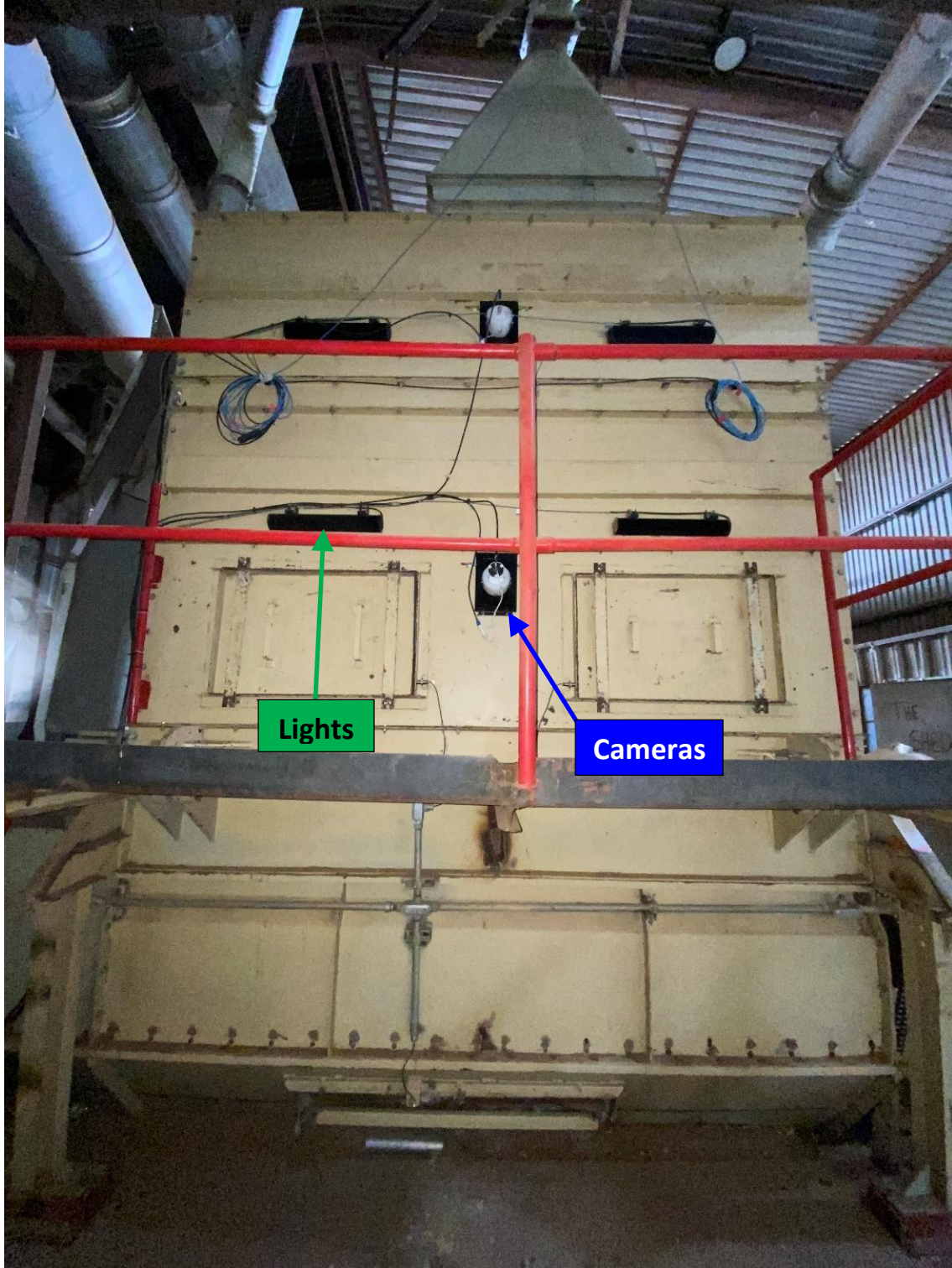


Figure 5a. Exterior photo of module feeder inspection system cameras and lights installed on the back wall of a module feeder.



Figure 5a. Interior photo of module feeder inspection system cameras and lights installed on the back wall of a module feeder.

6. System Installation Recommendations

The following points provided improved system performance during testing at commercial gins:

- Use of the optional supplemental air nozzle provided some cleaning of the lens protector but we observed two potential issues with its use: 1) mud may accumulate on the lens protector if the air supplied to the nozzle is not free of oil and water, and 2) when dust and other particles inside the feeder mix with the compressed air from the nozzle, the surface of the lens protector can be abraded and become cloudy thus blocking a portion of the camera view. We observed that the lens protectors were kept adequately clean without the use of the air nozzle through the scrubbing action of the cotton falling away from the dispersing cylinders.
- While use of the lens protectors is not mandatory, their use is highly encouraged to extend the life of the cameras. The lens protectors functioned well during the 2020 ginning season and required replacement only once, about mid-way through the season due to abrasion from the supplemental air nozzles. The lens protectors remained clear after replacement and discontinued use of the supplemental air nozzles. None of the cameras installed failed due to broken lenses or damage caused by impact (no camera failures were experienced in 2020).

- During installation, the lens protectors were sealed to the face of the cameras using thin film packing tape. This helped to keep dust from collecting between the lens protector and the camera lens.
- Place indicator marks on the back housing of the camera and camera sleeve so that the camera can be returned to the same position in the event that it must be removed for service.
- If the back wall to dispersing cylinder distance is adequate to allow for camera and light positioning according to figure 4a, placing the cameras higher on the back wall of the feeder will reduce maintenance requirements.
- Supplemental light with uniform coverage in the lower dispersing cylinder area is critical to obtaining clear images. Additional lights may be needed in some module feeder configurations to provide adequate lighting. Hand placement of lights while determining camera positions before final installation will provide insight as to the amount of extra light that may be needed and help to provide more uniform light coverage.

7. Discussion: Impact of System on Plastic Contamination

The module feeder inspection systems installed for testing in 2019 and 2020 provided significant benefits to the gin staff at each gin by improving their ability to see and quickly act to remove potential contaminants from the dispersing cylinders. The updated system discussed herein, provides additional installation flexibility allowing for easier installation into different feeder designs. In all cases, the gins experienced a significant drop in the number of plastic calls after installation of the systems compared to prior years.

Component and assembly drawings for the adjustable camera mount and bill of materials table are shown in figures 6 – 13 and table 1, respectively. Additional details on LED light bars and power supply units are shown in table 2.

8. Future Development - Automatic Module Feeder Inspection System [To be released Q4 2021].

The automatic module feeder inspection system builds on the functionality of the basic system by adding custom software that interfaces with the module feeder PLC to automatically pause the feeder floor and capture still images of the dispersing cylinders. One way this can be accomplished is to incorporate a pause routine into the module feeder PLC program which, when enabled by the ginner, pauses the feeder floor for a specified number of seconds on a user set frequency (e.g. every 20 minutes). When the feeder bed pauses, the module feeder inspection system software senses the pause event and captures still images from the network IP cameras automatically once a clear view of the dispersing cylinders is obtained. Alternatively, the system could be configured to sense the motor load on the dispersing cylinder drive and trigger image captures from the network IP cameras when the motor load remains below a specified level long enough to provide a clear image of the cylinders. When this development is finished, it will also include automatic detection of plastic on cylinders and provide an external relay to trigger an alarm beacon to alert the gin crew of the presence of plastic on the cylinders.

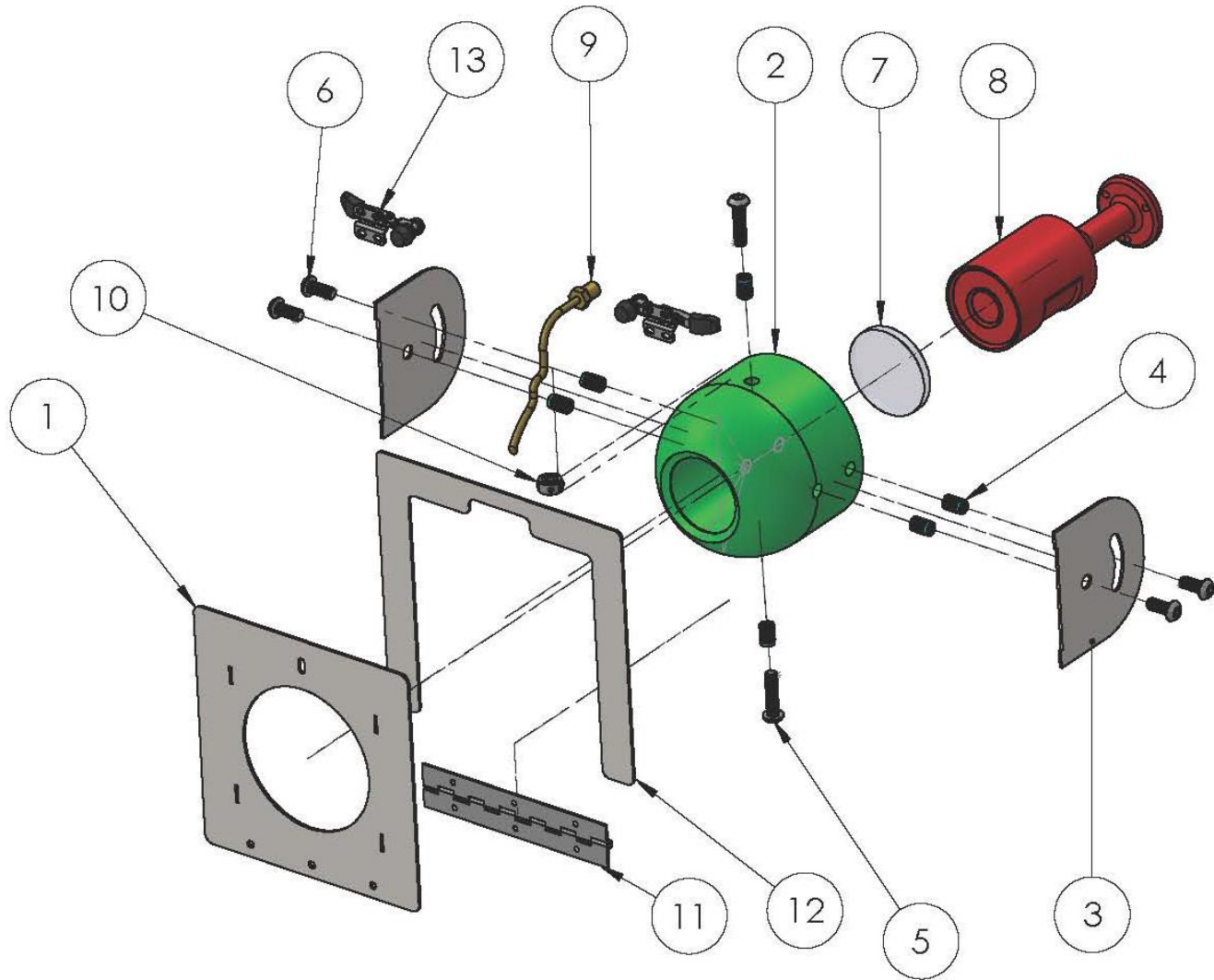


Figure 6. Exploded view of the adjustable camera mount.



Table 1. Bill of materials for the adjustable camera mount used in the module feeder inspection system.

Item No.	Part Description	Quantity per Assembly	Estimated Unit Cost	Source/Material Link
1	Camera Face Plate V2	1	\$ 15.00	Shop Fabricated, 14 ga mild steel
2	Camera Sleeve v2	1	\$ 156.17	Shop Fabricated, https://www.mcmaster.com/8701K63/
3	Sleeve Hinge Plate V2	2	\$ 8.00	Shop Fabricated, 14 ga mild steel
4	92395A030 - Threaded insert, 5/16 - 18 thread	6	\$ 0.70	https://www.mcmaster.com/catalog/127/3568
5	91306A404 - 5/16 - 18 x 1.25 in - Button Head Hex Drive Screw, Zinc Plated	2	\$ 0.45	https://www.mcmaster.com/catalog/127/3240
6	91306A387 - 5/16 - 18 x .75 in - Button Head Hex Drive Screw, Zinc Plated	4	\$ 0.34	https://www.mcmaster.com/catalog/127/3240
7	Camera Lens Protector_0.25 in	1	\$ 13.17	Shop Fabricated, https://www.mcmaster.com/8536k164
8	IP Camera (Dahua, N42BD32)	1	\$ 109.00	https://www.amazon.com/Dahua-Technology-N42BD32-Outdoor-Connection/dp/B08MQS664M
9	3_16 OD nozzle - Mid Cam Elevation	1	\$ 7.88	Shop Fabricated, https://www.mcmaster.com/catalog/127/2923
10	6436K6 - 3/16" Split shaft collar	1	\$ 5.00	https://www.mcmaster.com/catalog/127/1338
11	1569A391 - Piano Hinge	1	\$ 2.72	https://www.mcmaster.com/catalog/127/3178
12	Door Stop Plate	1	\$ 12.00	Shop Fabricated, 14 ga mild steel
13	5128A620_Low-Profile Hold-Down Toggle Clamp	2	\$ 10.18	https://www.mcmaster.com/catalog/127/2789

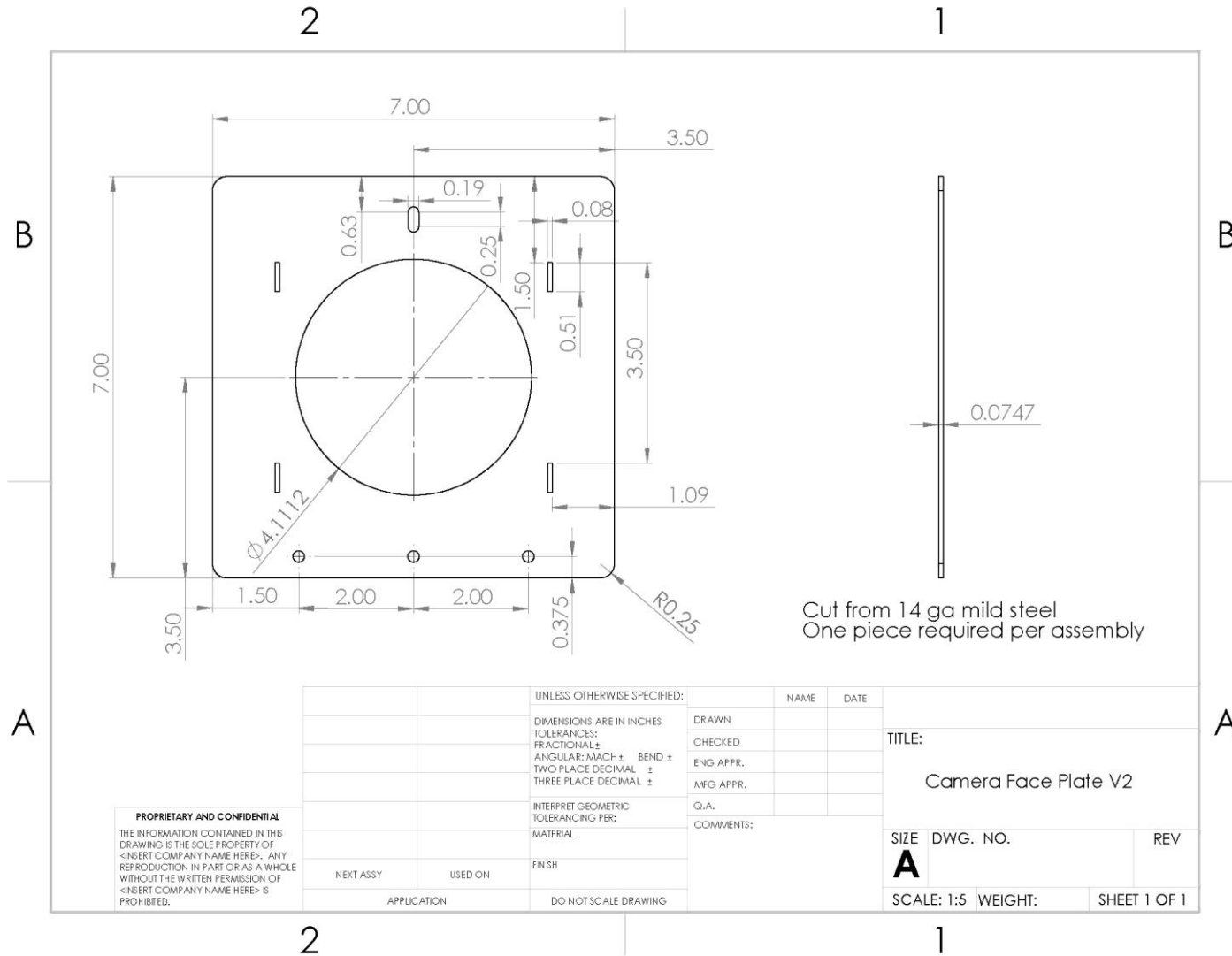


Figure 7. Camera Face Plate V2 component drawing (item 1, table 1).

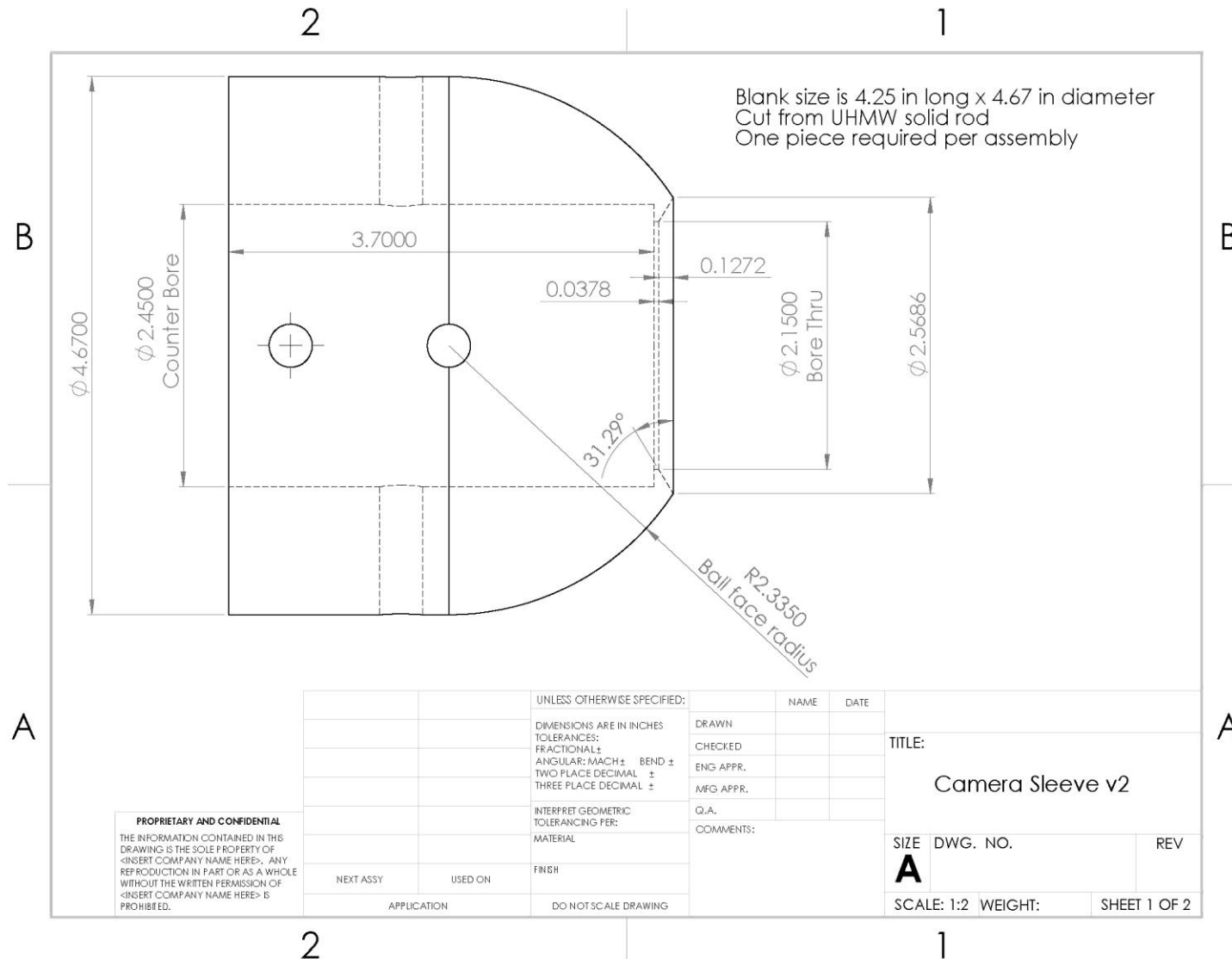


Figure 8a. Camera Sleeve V2 component drawing (item 2, table 1).

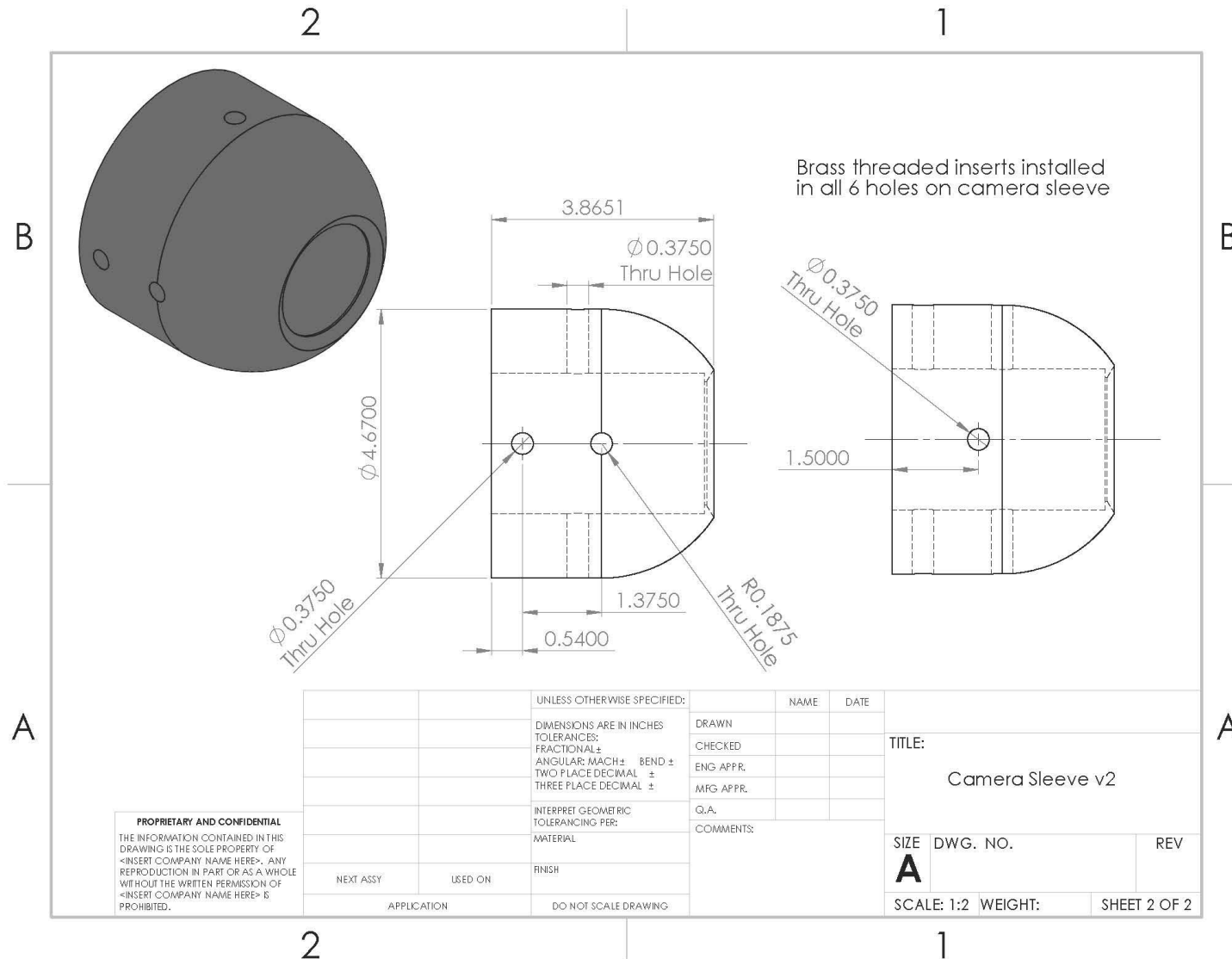


Figure 8b. Camera Sleeve V2 component drawing (item 2, table 1).

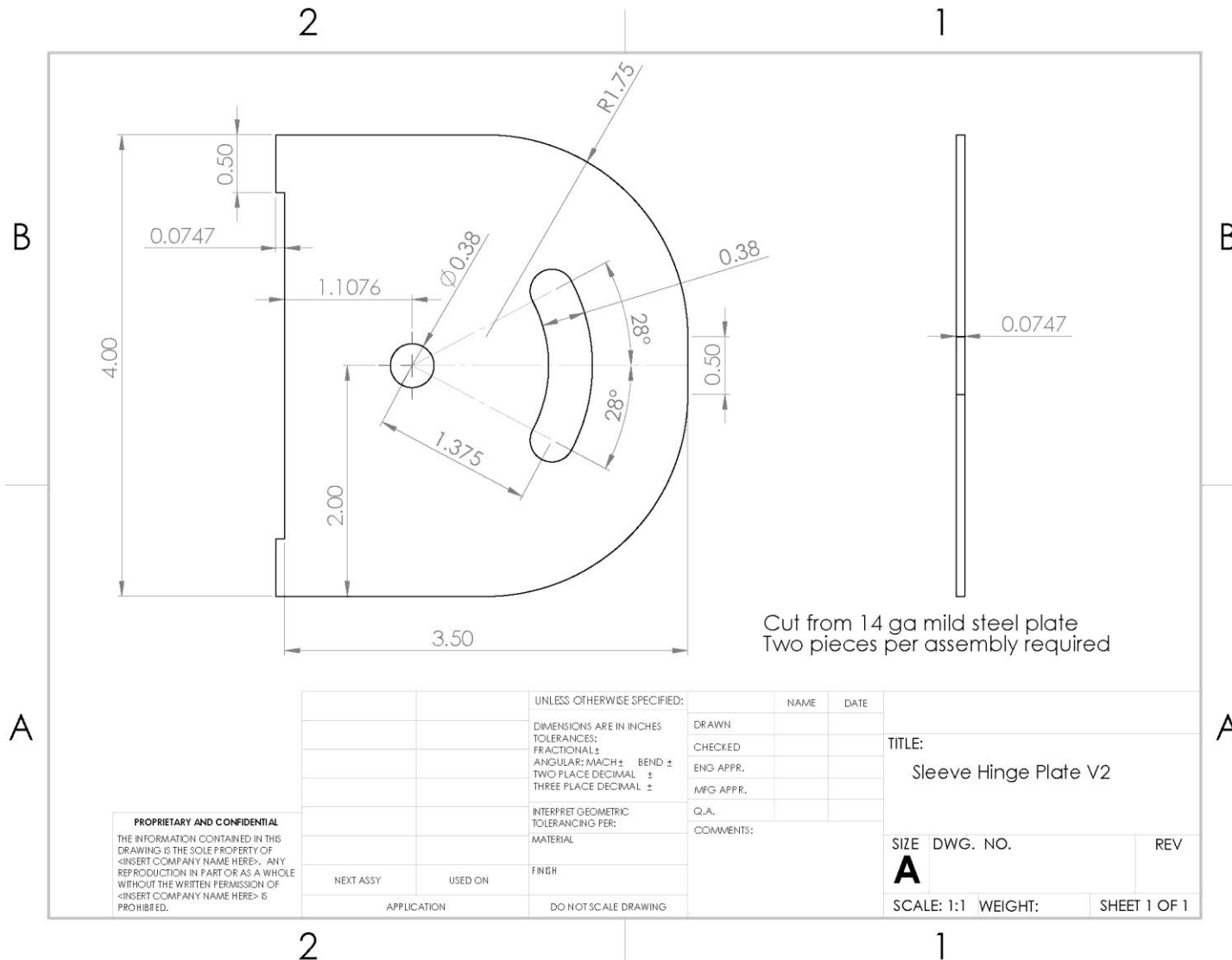


Figure 9. Sleeve Hinge Plate V2 component drawing (item 3, table 1).

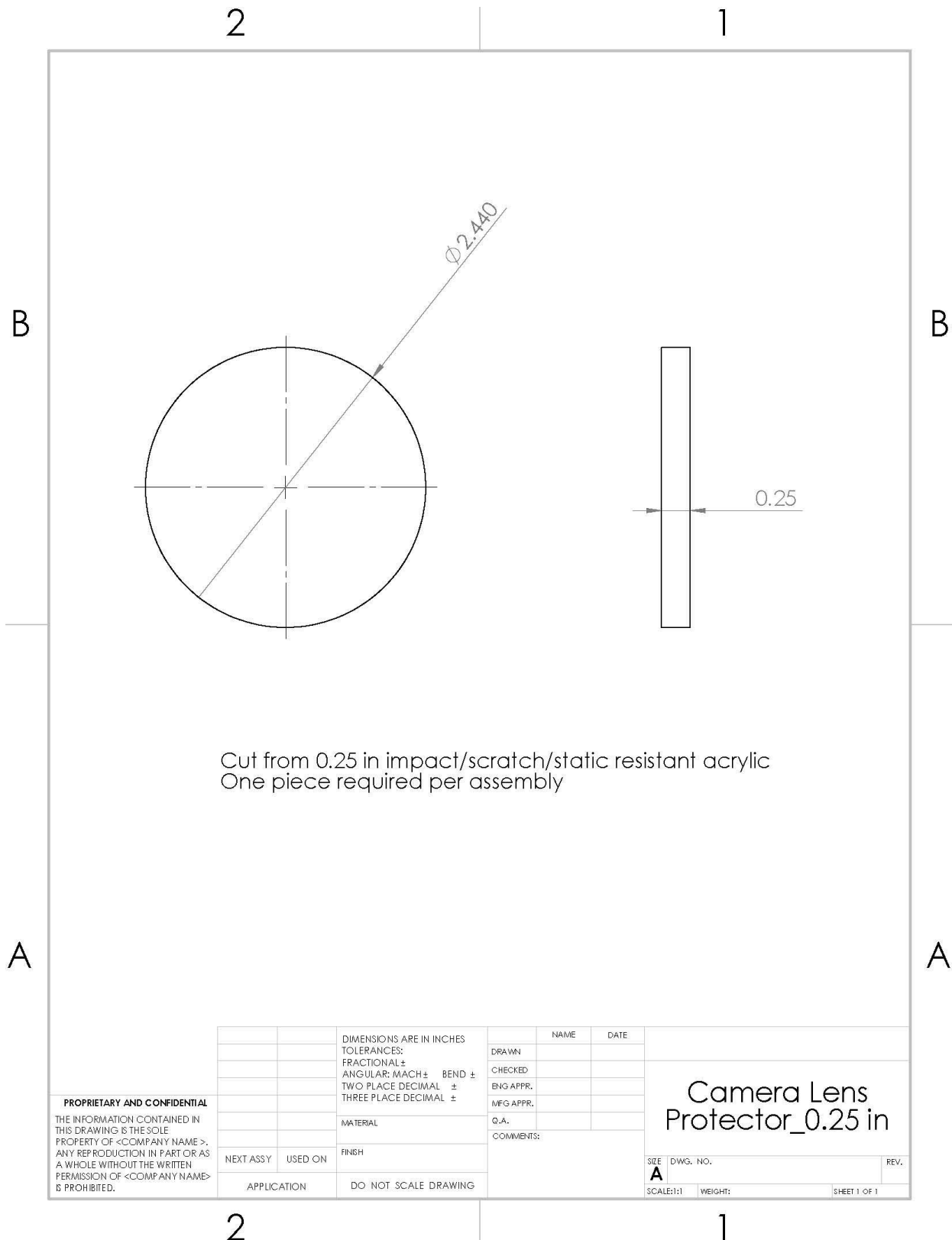


Figure 10. Camera Lens Protector_025 component drawing (item 7, table 1).

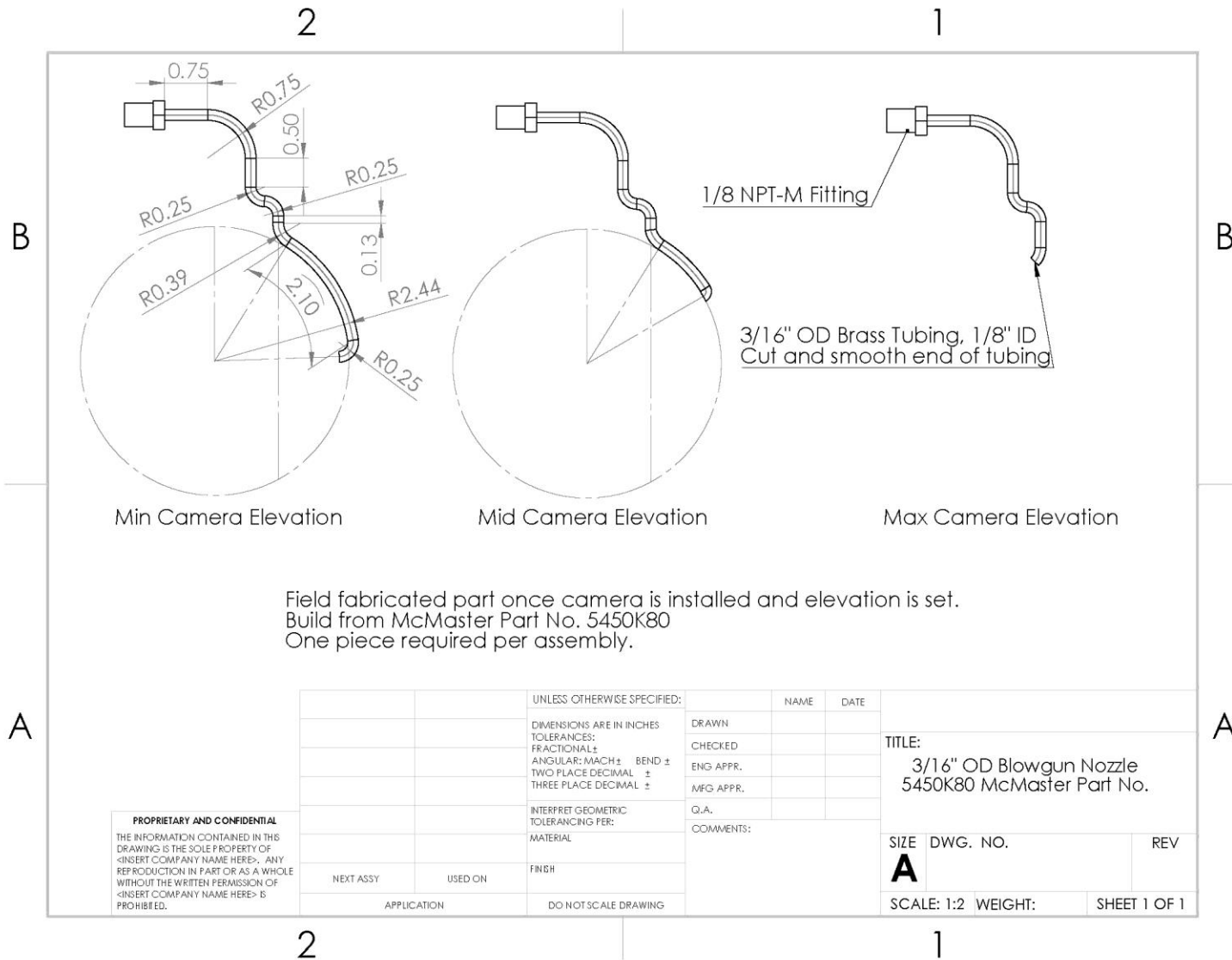


Figure 11. 3_16 OD nozzle - Mid Cam Elevation component drawing (item 9, table 1). Part is field-fit to match specific camera elevation when installed.

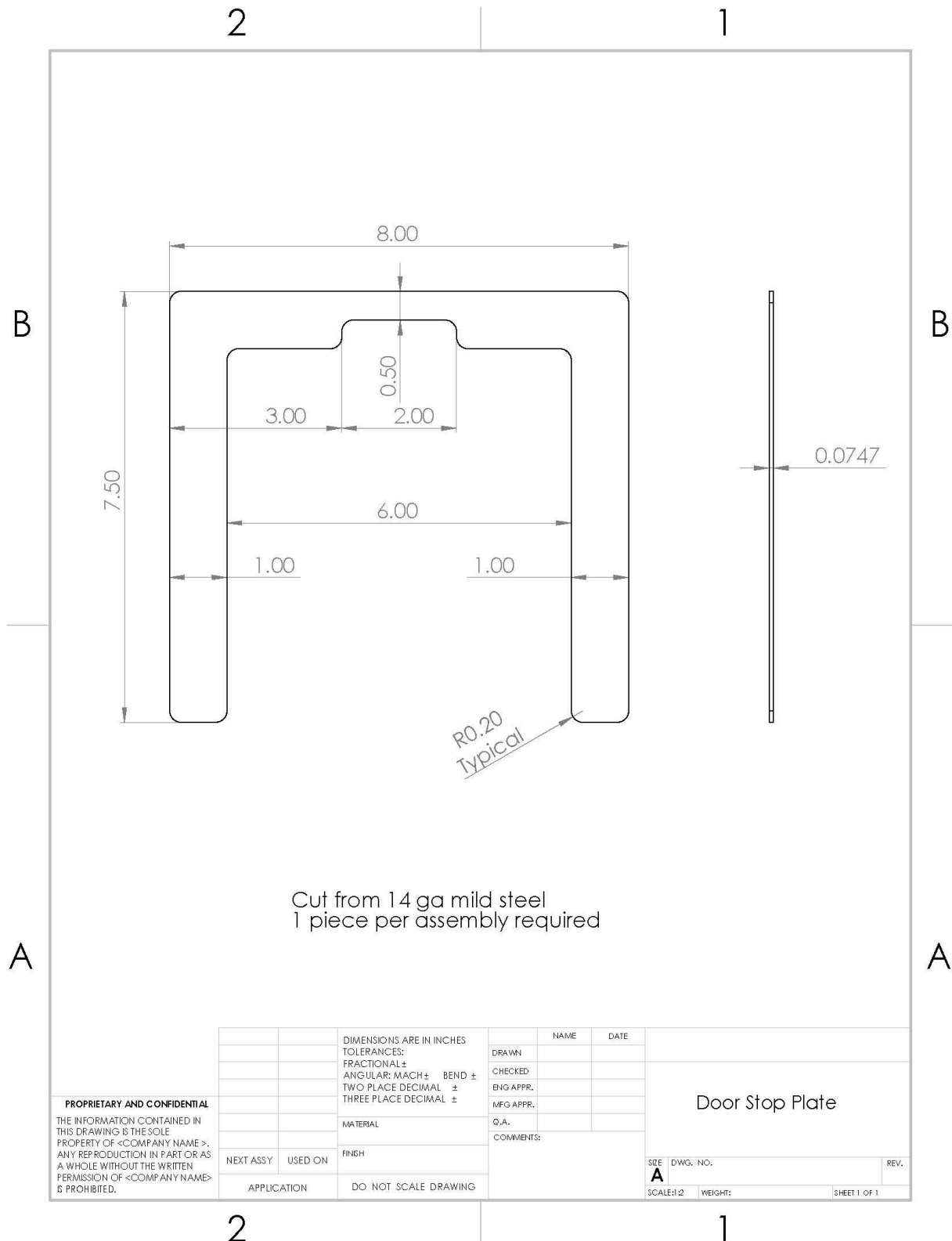


Figure 12. Door Stop Plate component drawing (item 12, table 1).

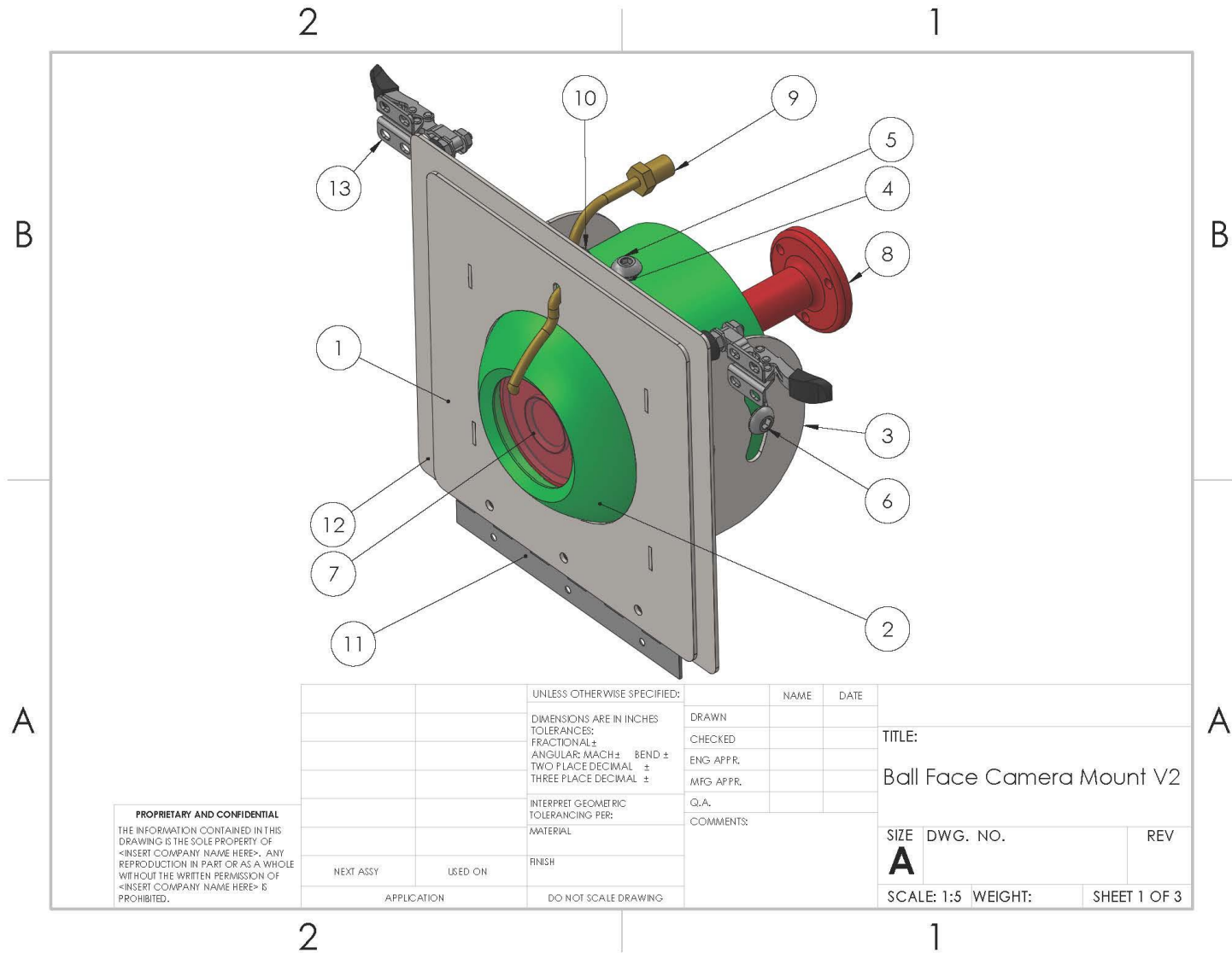


Figure 13a. Assembly details for adjustable camera mount.

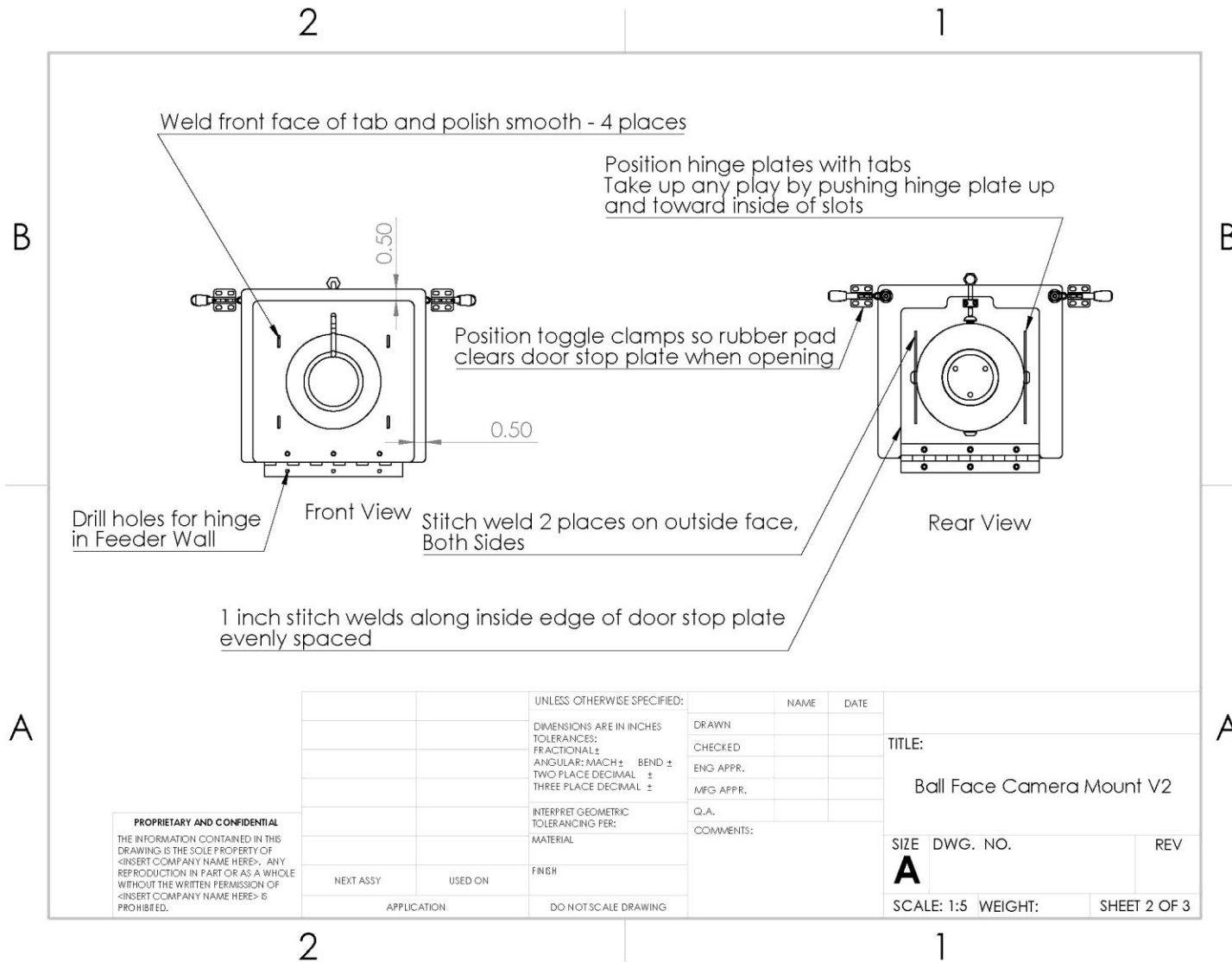


Figure 13b. Assembly details for adjustable camera mount.

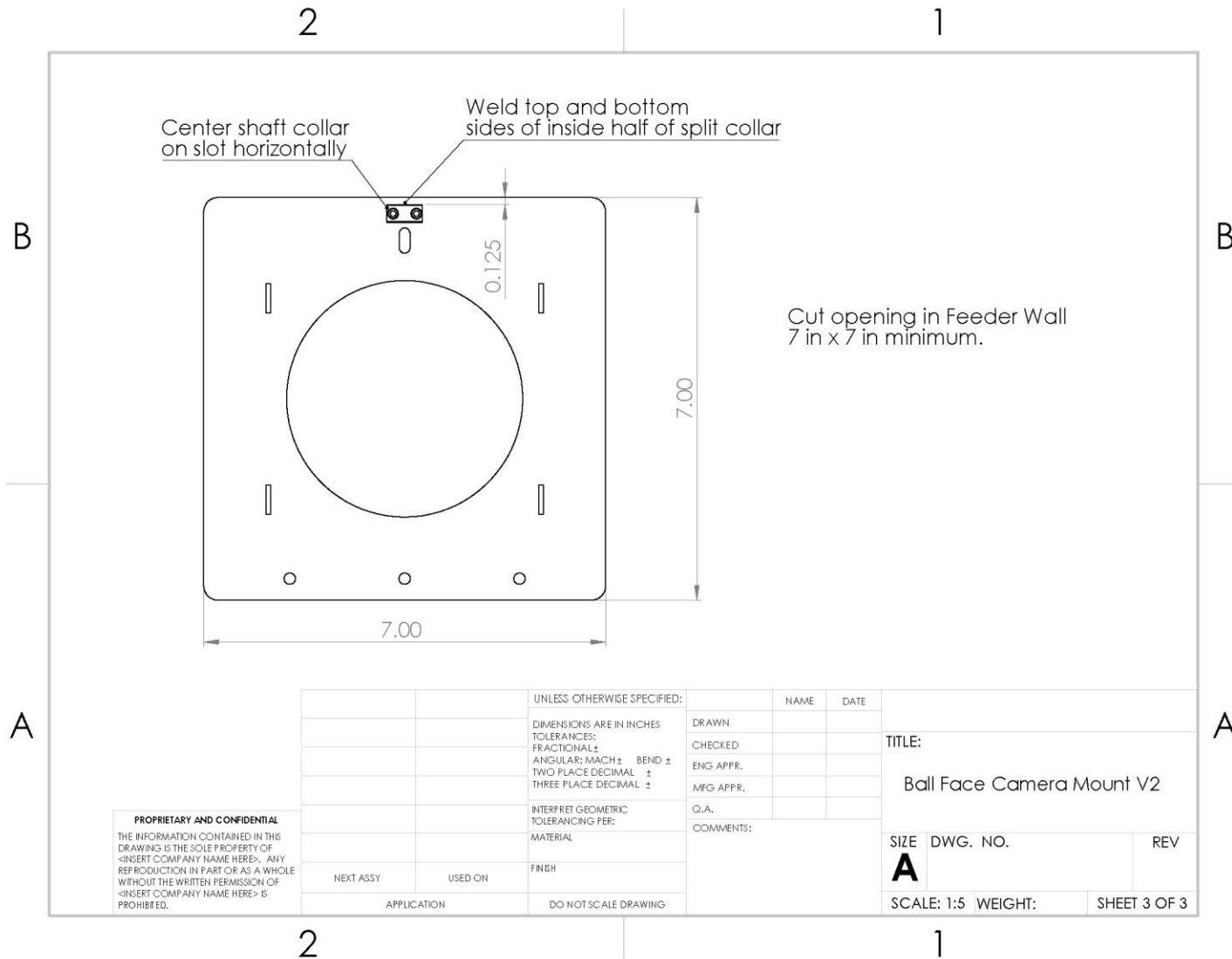


Figure 13c. Assembly details for adjustable camera mount.

Table 2. LED light and driver components for module feeder inspection system.

Part ID, Picture	Product Description	Price
	<p>Nilight – ZH006 LED Light Bar, 20 Inch, 126w LED, 10,000 Lumens</p> <p>https://www.amazon.com/Nilight-ZH006-20Inch-Harness-Warranty/dp/B06XQGTXQ/ref=sspa?dchild=1&keywords=led+light+bar&qid=1619027350&sr=8-3-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExRVBSSUFGRzQ1SEUmZW5jcnlwdGVkSWQ9QTA4NDM5NDI2SkEwWlk2WFIQTzUmZW5jcnlwdGVkQWRJZD1BMDIyMzYwODFGQ0U4VDdXQlA4SDImd2lkZ2V0TmFtZT1zcF9hdGYmYW9uPWNsaWNrUmVkaXJlY3QmZG9Ob3Rmb2dDbGljaz10cnVl</p>	<p>4 @ \$40 each</p>
	<p>Idealy 150W DC 12V Ip67 Waterproof LED Power Supply Driver Transformer</p> <p>https://www.amazon.com/Idealy-Waterproof-Transformer-Adapter-Lighting/dp/B08CRO45BD/ref=sr_1_1?dchild=1&keywords=Idealy+150W+DC+12V+Ip67+Waterproof+LED+Power+Supply+Driver+Transformer&qid=1619027531&sr=8-1</p>	<p>4 @ \$34 (1 per light)</p>