IALA COUNCIL
56th Session

December 9 - 13, 2013
Goa
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Agenda item 9 – IALA TECHNICAL ACTIVITIES

9.7 EEP

9.7.1 Documents submitted for approval

9.7.1-2 Draft Guideline 1006 Ed3 Plastic Buoys

Update October 2013

Note by the Secretariat

1 SUMMARY

This is an update of existing Guideline 1006 to correct reflect the latest practice. References to Guideline 1040 were deleted and replaced by references to Guideline 1077.

The Guideline describes the use of plastic in buoys of up to 3m diameter.

2 ACTION REQUESTED

The Council is requested to Approve the draft Guideline

International Association of Marine Aids to Navigation and Lighthouse Authorities

AISM Association Internationale de Signalisation Maritime IALA

IALA Guideline No. 1006

on

Plastic Buoys

Edition 3

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Document Revisions

Revisions to the IALA Document are to be noted in the table prior to the issue of a revised document.

Date	Page / Section Revised	Requirement for Revision
December 2005	Entire Document	Reformatted to reflect IALA documentation hierarchy
April 2008	Entire document	Review and update at IALA Floating aids 2008 workshop and EEP11/12.
December 2013	Pages 4,6,7,8 and 9	References to Guideline 1040 deleted and replaced by Guideline 1077

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3 INTRODUCTION

A plastic buoy may be defined as a floating aid with at least the hull being constructed of a plastic material.

Plastic buoys have been in production for over twenty years. They are produced in various materials and designs. Initially they were produced in small sizes, but nowadays there are several manufacturers producing plastic buoys in sizes up to and in excess of 3m diameter.

4 BACKGROUND

Many types of plastic buoys are available in the marketplace, ranging from small harbour or river markers, to large offshore buoys.

It is suggested that plastic buoys have several advantages over conventional steel buoys including; light weight handling, corrosion resistance, low maintenance, and in some cases, lower costs. However, these apparent advantages need careful evaluation.

4.1 Points to be considered when evaluating plastic buoys

1. Light weight buoys need careful design to avoid having a rapid rolling or pitching motion detracting from their navigational effectiveness in waves, wind and current.
2. A well-manufactured buoy using high-quality pigment within IALA chromaticity standards, and virgin material, should retain an acceptable surface colour for the design life of the buoy, which can be in excess of 15 years in most climatic conditions. However, high ultra violet exposure will accelerate the ageing process.
3. Some plastic materials may have better resistance to dense marine fouling than other buoy types. Plastic buoys must be sufficiently robust to withstand weed being scraped off, or high pressure water jetting, regularly during the working life of the buoy.
4. The purchase cost of plastic buoys is dependent on the construction technology. Whole life costs may be less than steel types; however users should carefully assess their requirements with costs factors.
5. Plastic buoy technologies offer flexibility to incorporate new design developments.
6. Some plastic spar buoys are particularly adaptable to certain ice conditions.
7. The mooring eye (or eyes) will usually be metal and must thus be fastened or moulded into the buoy by some means such that the internal structure to can safely transmit loads from lifting eyes to mooring eyes and to distribute mooring loads.
8. Handling plastic buoys may require new techniques. The safe working load on plastic buoys may be less than steel types.
9. Major service intervals may be governed by the life expectancy of the metals used in the buoy assembly.
10. Sea-based maintenance can be achieved on most plastic buoys, including jet washing and other normal service tasks. Various maintenance procedures are suitable for different plastic materials. More guidance is available in IALA Guideline No. 1077 *(The Maintenance of Buoys and Small Aids to Navigation Structures).*
11. The metal components will require a more intensive maintenance regime, therefore the grade of steel must be considered, depending on environmental conditions.(e.g. the mooring eye, either of 316L stainless steel or hot dipped galvanized steel.).
12. It may be necessary to incorporate an earthing strap on large plastic buoys to prevent the build-up of static electricity, which may cause shock or damage electronic equipment.

5 BUOY CONSTRUCTION MATERIALS

Plastic buoys may be grouped into four basic types which are listed with comments on their design and construction:

- Polyethylene
- Glass Reinforced Plastic (GRP)
- Polyurethane / elastomer coated foam
- All foam

5.1 POLYETHYLENE (Appendix 2, Figures 1, 2 and 3)

General

This well-known technique has been widely used to manufacture many types of buoys, in rotationally moulded or extruded polyethylene. Some manufacturers may then fill the buoy with polyurethane foam or polystyrene foam.

The polyethylene material may be linear (low, medium or high-density) or cross linked. The linear material has the advantage that it can be melted and hence repaired by hot fusion welding. The polyethylene material used in buoy manufacture is usually linear.

The polyethylene provides poor adhesion for conventional paints, but specialized hot plastic spraying processes are available and have been used successfully for black or white coatings. When colour is moulded-in, pigments must be of the highest quality suitable for marine use and UV exposure.

The roto-moulding process is also used to manufacture buoyancy modules which are attached to a structural core which may be in the form of a buoy or a resilient beacon.

The manufacturing process has been developed in recent years to allow the production of large floats (3m diameter) with wall thickness in the order of 10-20 mm which are now being used as the buoyancy element of substantial buoys. These floats may be manufactured in four segments to simplify handing and transport and allow a reserve of buoyancy should one segment be damaged.

For small buoys (<1 m diameter) the assembled weight of polyethylene buoys can be equal or higher than thin skin steel buoys.

Construction

Manufacturers typically construct polyethylene buoys from one piece plastic mouldings, modular plastic, or hybrid metal/plastic designs. Polyethylene material will expand and contract about 3 to 5%, depending on the colour and ambient temperature. Generally, small buoys are made in one piece, while larger types may be modular or hybrid designs.

The wall thickness of the buoy body must be proportional to the size of the buoy to be sufficiently robust. The thickness of the wall depends on the filling of the buoy, i.e. foam filled or not. For example foam filled to be between 6-12mm, and not foam filled be between 6-30mm, note that this should be proportional to the diameter of the buoy body of 500mm to 3000mm.

Polyethylene material will expand and contract with changes in temperature. Care should be taken in the design to ensure compatibility between different materials (e.g. elongated or oversized clearance holes).

5.1.1.1 Filling

To prevent the buoy sinking the buoy may be divided into separate watertight segments, which may be filled with foam. If foam is used, it must be of the highest quality closed-cell specification to prevent water absorption. Filling material should be of sufficient quality to survive the expected lifetime of the buoy. Some disadvantages may exist in the use of filling. Some polyurethane foam types may not be possible to recycle.

5.1.1.2 Fasteners / Mooring attachment

In the manufacturing process, care should be taken to ensure that threaded inserts are fixed and aligned correctly in the material, otherwise they should be avoided.

Care must be taken when using threaded inserts to avoid detachment of the insert within the polyethylene.

It is desirable to use non corrosive fasteners including hot-dipped galvanized steel, marine-grade aluminium, marine grade stainless steel or bronze.

It is important that any high loads are distributed throughout the structure of the buoy and not concentrated in small areas of the skin. One solution to avoid these stresses may be to interconnect the mooring and lifting points with a structural core member.

5.1.1.3 Quality Control

The manufacturing materials must be carefully specified and certification obtained from the manufacturer to ensure that correct quality virgin materials and UV stabilizers (in both the pigment and the polyethylene) have been used.

Repair & Maintenance

- Linear polyethylene can be easily repaired by trained technicians using hot fusion welding equipment in required colours.
- Maintenance procedures are outlined in IALA Guideline No.1077.

Handling

There are no specific requirements.

Recycling / Disposal

Linear thermoplastics can be recycled, however it must be possible to separate any metal components and impurities (marine growth / paint etc) from the plastic, and remove any internal filling.

Health and Safety

Reference to available material datasheets should be made prior to making any repairs or when handling any polyurethane filling material (e.g. disposal, fusion welding).

5.2 GLASS REINFORCED PLASTIC (GRP) (Appendix 3, Figure 4)

General

GRP is the usual abbreviation for glass reinforced plastic which in its most common form consists of glass matt bonded by polyester resin.

Construction

Complex shapes can be easily produced by laying-up resin and glass reinforcement into a mould by hand (or spray machine). The cylindrical buoy body is usually formed by joining two half body shapes. It is important to note that the join is often the weakest area of the body.

The strength of GRP is basically dependent of the ratio of glass fibre to resin and thus this is another area which requires definition and quality control. High strength (required in ice conditions) can be achieved by the use of carbon or Kevlar fibres, but their costs may be high. These fibres may be used in specific stress areas of the buoy.

The outer layer of resin, the gel coat, prevents water absorption into the glass reinforcement and must be protected from mechanical damage. This is usually provided by some form of fendering.

5.2.1.1 Filling

In the event of a collision, a GRP buoy may well crack from an impact which would only dent a steel buoy. To prevent the buoy sinking the buoy should be divided into separate watertight compartments or filled with polyurethane foam or polystyrene foam. If foam is used it must be of the highest quality closed-cell specification. If the foam is porous it may absorb water over a long period of time and increase the weight of the buoy to such an extent that it cannot be lifted by the servicing craft, or the buoy may sink.

5.2.1.2 Fasteners / Mooring attachment

Care must be taken when bonding metal attachment points into GRP due to the considerable difference in thermal expansion rates between metals and plastics, and the inherent flexibility of the GRP. Another option is to use through bolted fixings with generous backing plates and resilient washers or coatings between the metal and the GRP.

It is desirable to use non corrosive fasteners including; hot-dipped galvanized steel, marine-grade aluminium, marine grade stainless steel or bronze.

Similar problems may exist with the fastening of lifting eyes and tower type superstructures. It is important that any high loads are distributed throughout the structure of the buoy and not concentrated in small areas of the skin. One solution to this problem is to incorporate a central (usually steel) spine to connect the mooring eyes, lifting eyes and superstructure.

5.2.1.3 Quality Control

As many commonly available types of glass fibre and polyester resin have limited resistance to extended immersion in water, the manufacturing materials must be carefully specified and certification obtained from the manufacturer to ensure that correct quality materials have been used. Confirmation must also be obtained that laminating and curing has taken place in the correct environment.

Repair and Maintenance

GRP buoys will require cleaning, repainting and any necessary repair to the gel coat.

Repair of GRP is usually straightforward but does require standards of cleanliness and specific working temperatures. Effective drying of damaged laminates or foam cores may also be difficult in cold climates. It may be necessary to use heaters to warm and dry damage areas and to ensure effective curing of the repair.

The final surface colour of GRP buoys can be incorporated into the gel coat. If this not the case or if a colour change is required, then buoys will require normal painting to achieve the required surface colours.

GRP buoys may be cleaned onsite using water jetting, however care should be taken to ensure paint flakes and surface materials avoid polluting the surrounding environment.

The area in which a foam filled buoys are used must be considered as oily water in around the Port environment could penetrate the damaged buoys, making the repair of it very difficult.

Maintenance procedures are outlined in IALA Guideline No. 1077.

Handling

Care should be taken to avoid damage to the GRP through impact due to its rigidity.

Recycling / Disposal

Crushed GRP may be used as a component for road construction. Therefore, it may be considered as a recyclable material.

Health & Safety

The use of laminating resins and solvents is subject to increasing control by health and safety regulations.

5.3 POLYURETHANE / ELASTOMER COATED FOAM (Appendix 4, Figure 5)

General

These buoys typically consist of a thick, flexible marine grade polyurethane elastomer skin on a flexible closed cell foam core. They have the advantage of overall flexibility and resilience. The flexibility will also be an advantage when the buoy has to be lifted or serviced in rough weather.

Construction

The buoys are usually manufactured by spraying the polyurethane skin material onto a shaped foam core and can thus be made to almost any required shape without the need for an expensive mould.

In the manufacturing process, particular attention must be made to the attachment or the interface between the flexible skin and steel mooring eyes. This requires very careful design to prevent water penetration into the foam or tearing of the skin.

The quality of the skin and foam materials is of the utmost importance. The consequences of failure of the skin are self evident but poor quality foam may absorb water through an apparently sound skin or may simply shrink, resulting in a wrinkled buoy with a considerable loss of buoyancy!

5.3.1.1 Fasteners / Mooring attachment

The points noted regarding mooring eyes on GRP buoys apply equally to these buoys. The concept of a central structure steel spine between the mooring and lifting eyes is commonly employed.

Repair &maintenance

Polyurethane may be repaired with two component pouring or trowelling compounds. Correct working conditions are critical (temperature and humidity) and detailed health and safety precautions must be observed.

Maintenance procedures

These are outlined in IALA Guideline No. 1077.

Handling

There are no specific requirements

Recycling / Disposal

Polyurethane products are difficult to recycle.

Heath & Safety

The manufactured polyurethane products present no particular health and safety risks in normal use, but are hazardous if ignited.

5.4 ALL FOAM (Appendix 5, Figure 6, Figure 7)

General

The life and durability of the buoy is entirely dependent on the quality of the foam used. The flexibility of the foam can provide good impact resistance but resistance to aggressive abrasion is not good. This last factor is important for buoys which will dry out on a hard bottom at a tidal site or may be subject to moving ice conditions.

A foam buoy hull can sustain considerable damage or loss of material without sinking. A damaged buoy may be repaired or recycled by the manufacturer. Other advantages of foam buoys include their lighter weight which may result in good performance in fast water.

Construction

These buoys are usually constructed by wrapping closed-cell foam around a central structural core, the layers of foam being heat sealed together during the wrapping process. A major US manufacturer uses ionomer foam which is produced in sheet form. The outer layer of the rolled foam shapes can be "densified" through the application of pressure and heat to make a hard, smooth surface. Pigments are usually incorporated into the foam during the extrusion process, so the colour is continuous throughout the entire hull and daymark. The buoys include a structural steel framework, steel lifting and mooring eyes, and stainless steel connecting hardware. Internal radar reflectors can be mounted in the daymarks.

The manufacturing technique particularly lends itself to the production of one-off designs as a variety of body shapes can be made without the need for a mould. Buoys of this type are significantly lighter than steel buoys of the same size.

5.4.1.1 Fasteners / Mooring attachment

Please refer to the section on polyurethane /elastomer coated foam (Section 3.3 refers).

Repair and maintenance procedures

These are outlined in IALA Guideline No. 1077.

Handling

There are no specific requirements.

Recycling / Disposal

The product is generally recyclable through the manufacturer.

Heath and Safety

There are no specific issues.

APPENDIX 1 **Advantages and Disadvantages of Plastic Buoys**

ADVANTAGES

- Plastic does not corrode;
- It is easier to maintain; only removal of marine growth, no painting on station;
- The complete maintenance can be carried out at sea if suitable vessels are available;
- There is less maintenance on shore for the plastic component (no grit blasting, no painting with the exception of GRP) therefore less resources may be utilised;
- Plastic buoys are of lower weight (1/2 to 1/3 mass of the equivalent diameter steel buoys). Therefore, the service may be able to use smaller buoy tender;
- Whole life costs may be less than steel buoys;
- France and The Netherlands, amongst others, have more than fifteen years experience of operating rotationally moulded polyethylene (PE) plastic buoys successfully;
- There are a number of commercial companies offering large rotationally moulded plastic buoys;
- Most plastic is recyclable;
- Where plastic buoys are of modular construction, it is possible to change individual parts or segments if they are damaged or need refurbishment;
- Large modular buoys are easier to transport and store, as parts can be disassembled for transit;
- The number of spare parts (whole buoys held) can be reduced;
- It is possible to encase a radar reflector within a plastic buoy's superstructure.

DISADVANTAGES

- Due to the lighter weight of plastic buoys, there may be more motion on station; however this may be mitigated in the design;
- It is more difficult to change the colour of a plastic buoy, as conventional painting is not reliable for plastic surfaces;
- On current estimates, plastic buoys have a shorter lifetime than steel buoys;
- Plastic buoy components will be specific to each manufacturer and may therefore, not be interchangeable;
- Plastic buoys are poor radar targets, thereby requiring a radar reflector, if radar recognition is required;
- GRP buoys are prone to impact damage, extreme hot and cold weather damage and aging with prolonged UV exposure which degrades the surface finish, which can cause fibreglass splinters injuring servicing personnel.

APPENDIX 2 **Examples of polyethylene buoys**

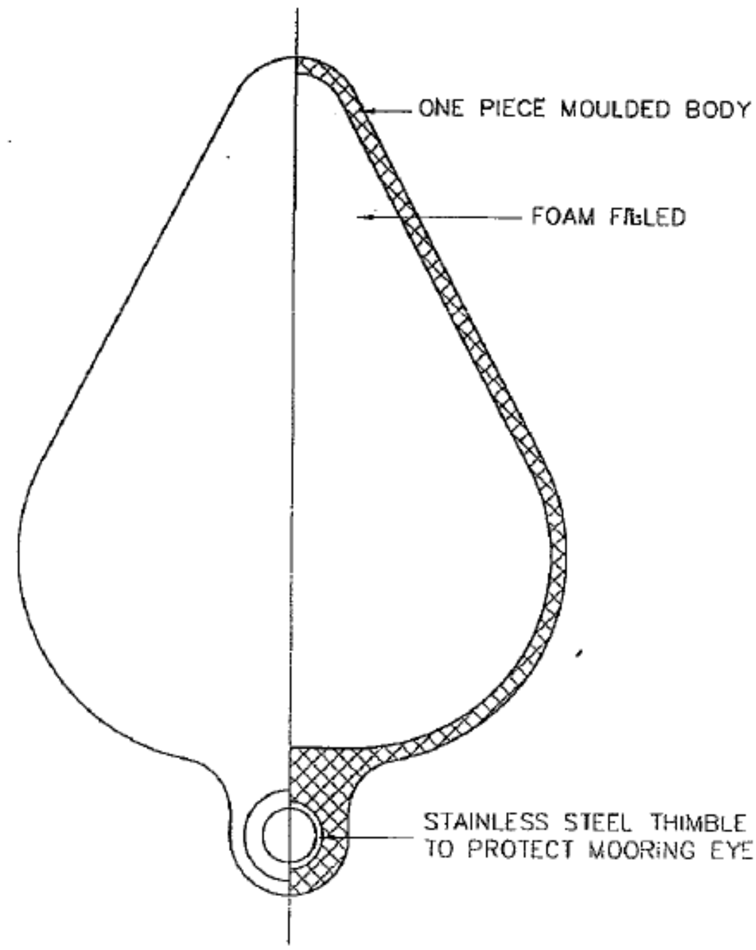

Figure 1 Small Rotationally Moulded Buoy

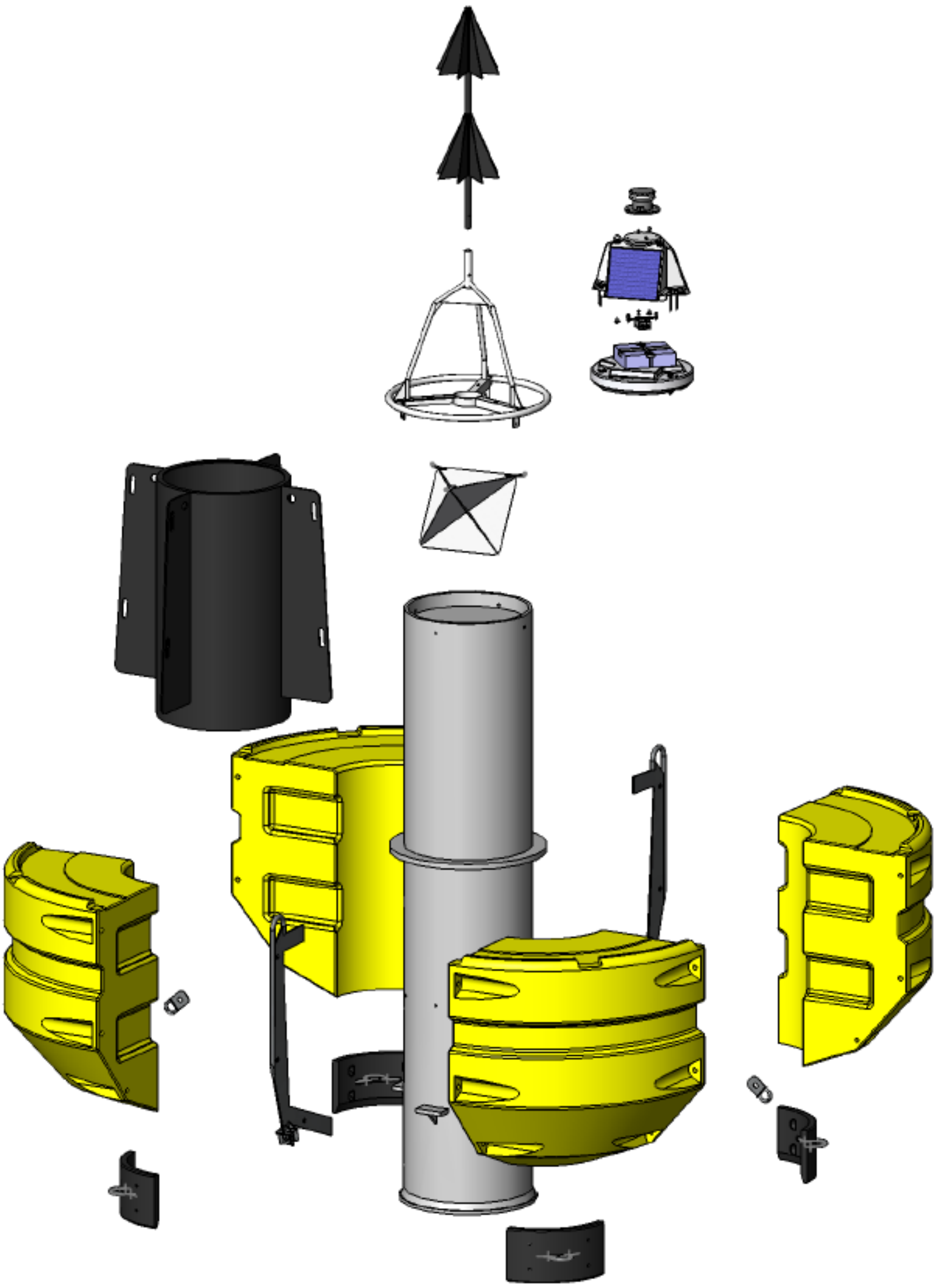

Figure 2 All Polyethylene Modular Buoy (except cast iron ballast and steel mooring and lifting eyes)

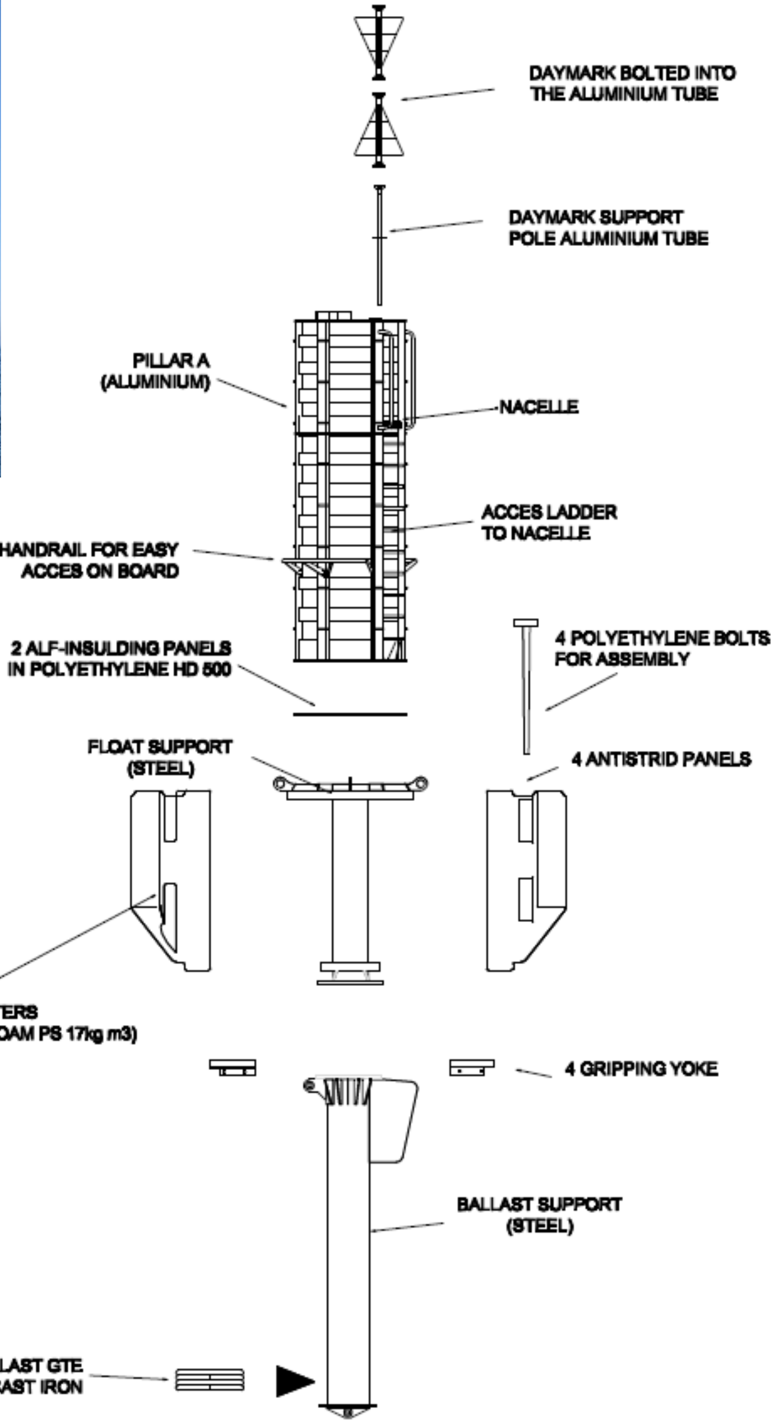

Figure 3 Modular Buoy

APPENDIX 3 **Example of Glass Reinforced Plastic (GRP) buoys**

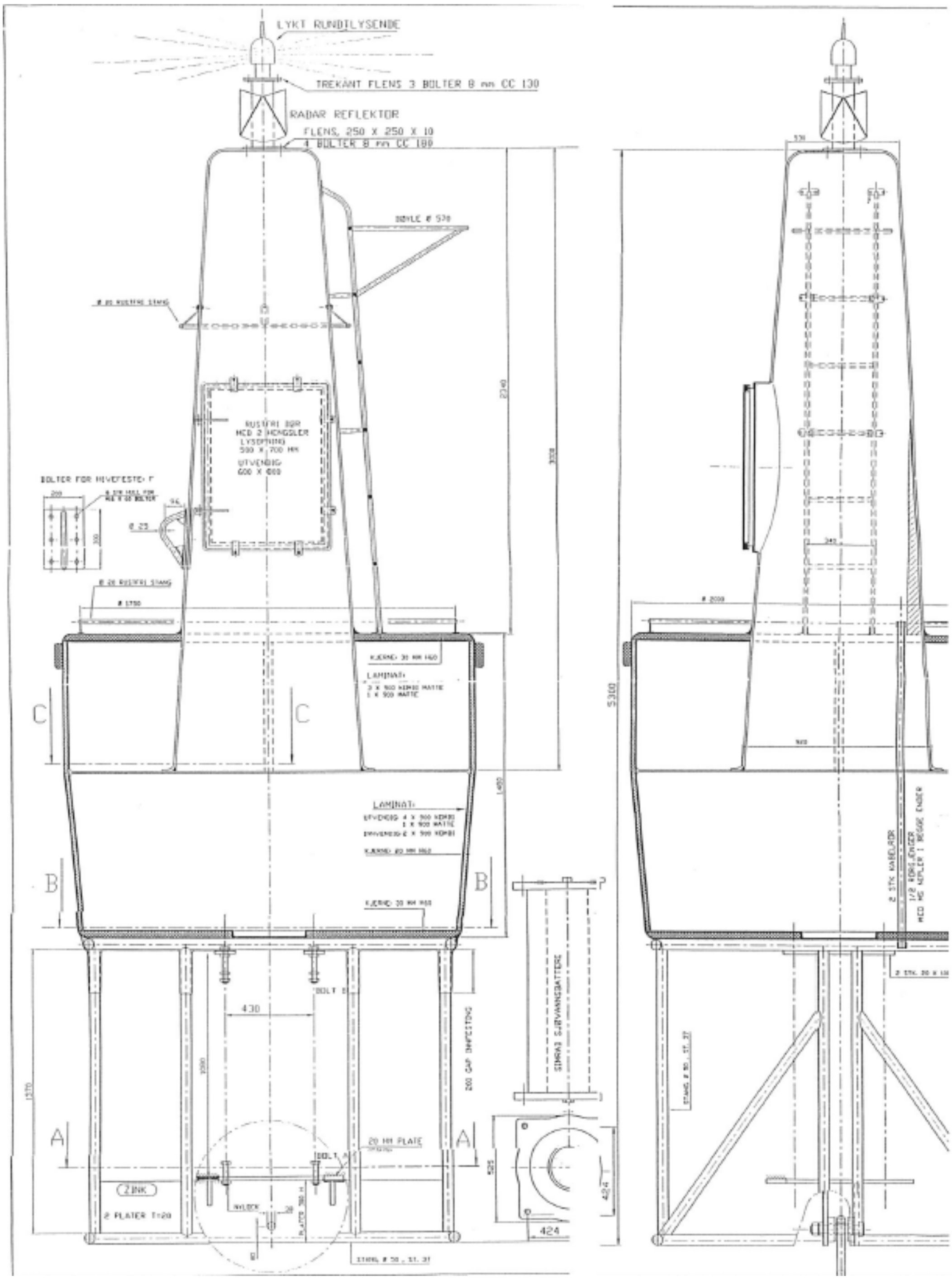

Figure 4 Large Glass Reinforced Plastic Buoy (Polyurethane Foam Filled)

APPENDIX 4 **Example of polyurethane / elastomer coated foam buoys**

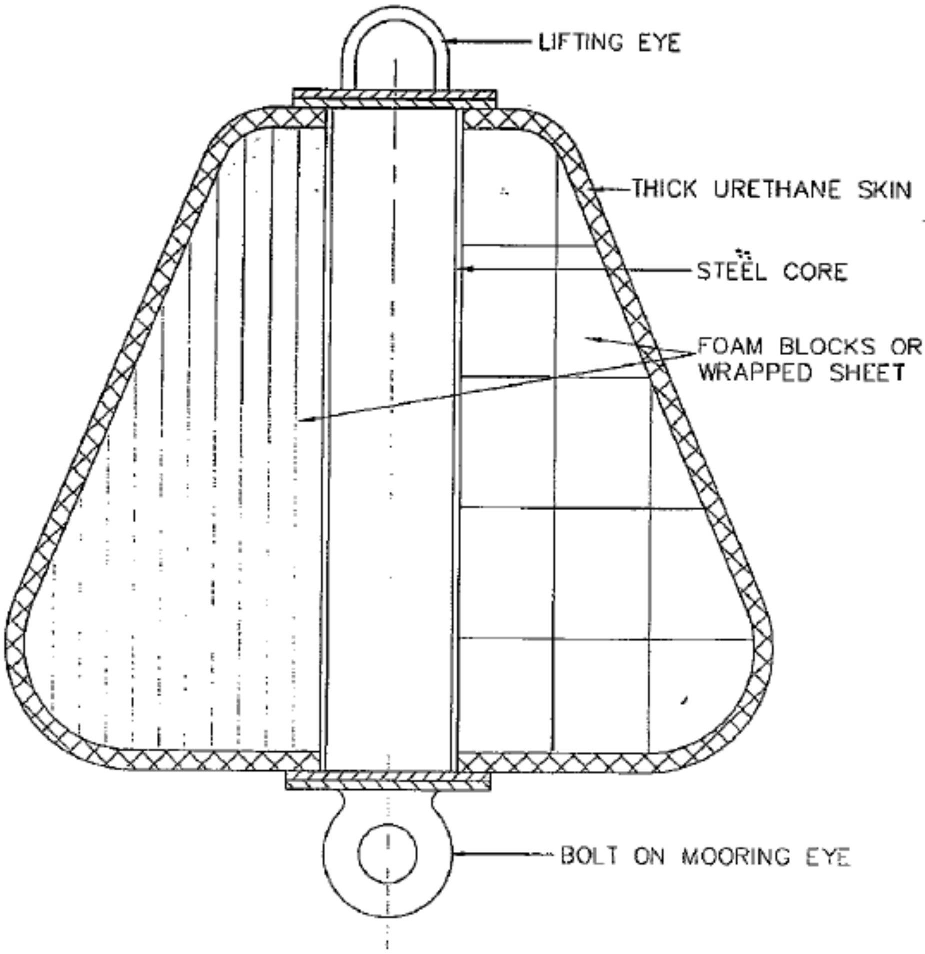

Figure 5 Small polyurethane / elastomer coated foam buoy

Note: Large polyurethane / elastomer coated foam buoys are also available

APPENDIX 5 Example of foam buoys

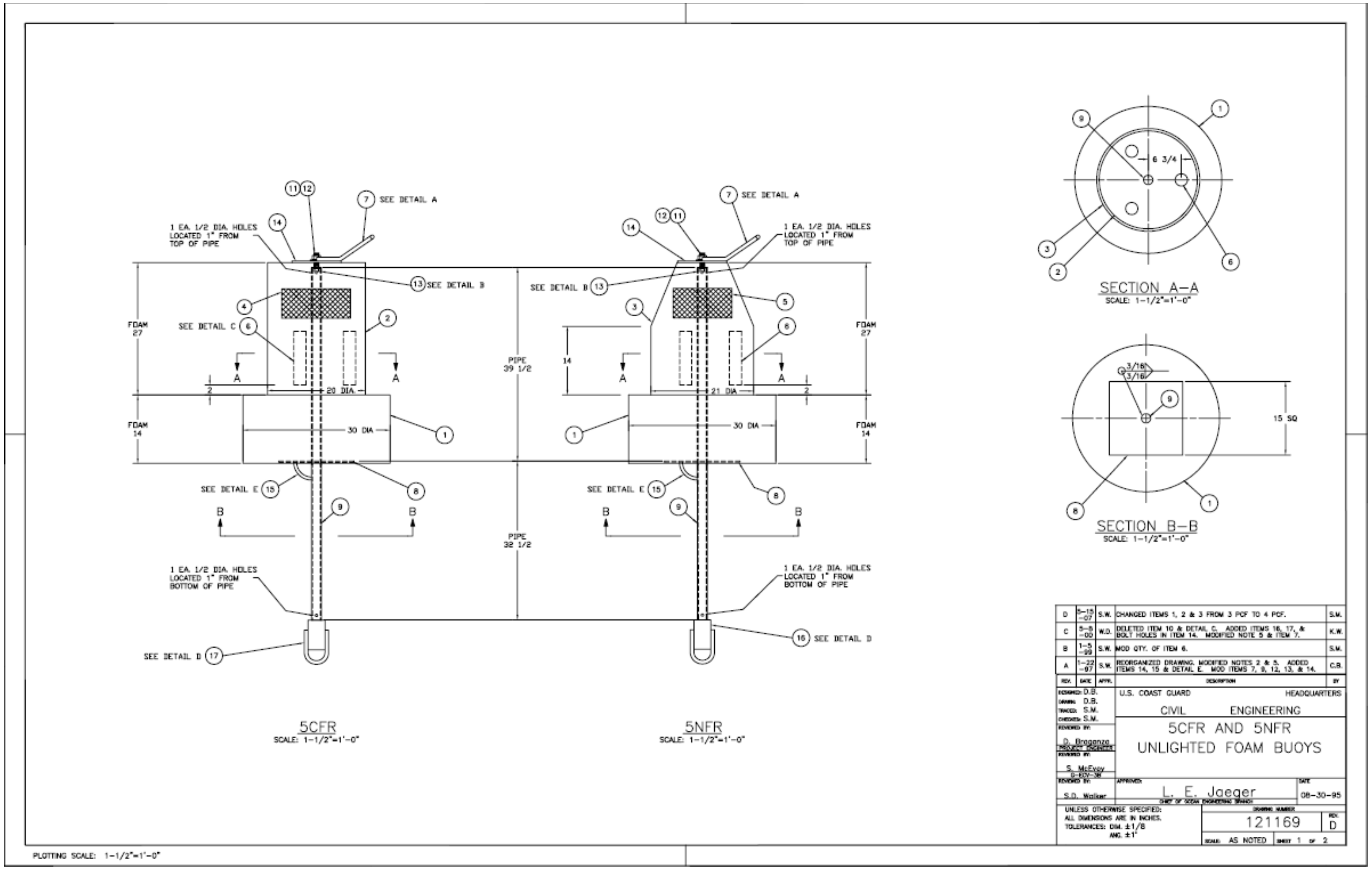

Figure 6 Foam Buoys from 0.75m to 1.6m diameter

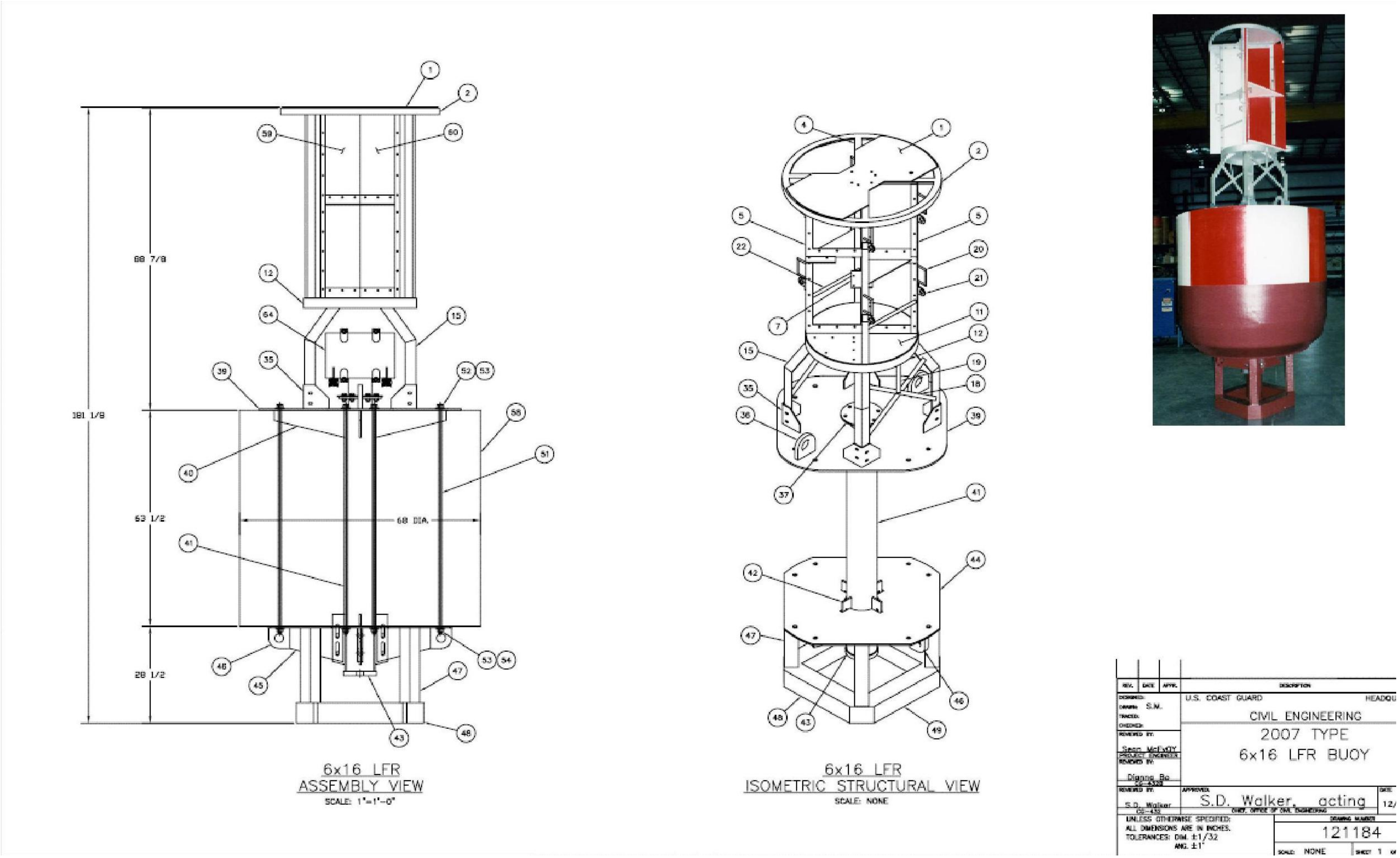

Figure 7 Large Modular foam buoys