ME2.02 – Logan Mallow, Claudia Quilter, Andres Herrera, Ryan Beakley

Design and Fabrication of Diver Below Buoys

BACKGROUND

What is the Problem?

- Legacy diver-below buoys are no longer manufactured
- Readily available products are insufficient
- Current buoy is experiencing corrosion and environmental degradation

What is a Diver Below Buoy?

- Location/Perimeter Marker
- Resting Platform
- Safety Mechanism

Mission Statement

Design, manufacture, and install six durable diver-below-buoys to support 3 to 4 divers, provide stable flotation, storage, and durability for long-term reliability and cost efficiency.

FINAL DESIGN

- Red marine grade, vacuum molded HDPE shell
- Marine grade closed cell foam core
- 3 feet in diameter
- Supports 4-5 divers
- Resistant to galvanic corrosion, UV degradation, rips, tears, and punctures
- Product life of 7-10 years

Cost Analysis

Annual Estimated Maintenance Cost

Currently in use buoys	$950- $1,200.00
General market buoys	$2,000-$2,500
Our Buoys	$0.00

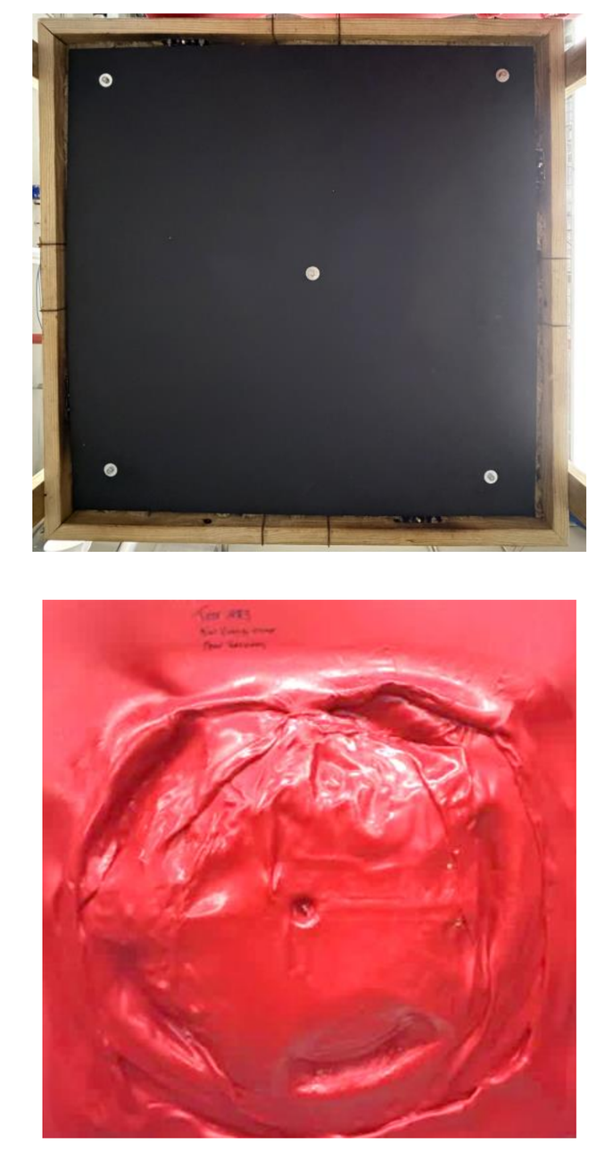
Per Unit Cost

Currently in use buoys	$495.00
Our Buoys	~$300.00

VACUUM FORMING MACHINE DEVELOPMENT

Heating Array Systems Test

TEST 1
Uneven heating of plastic sheet

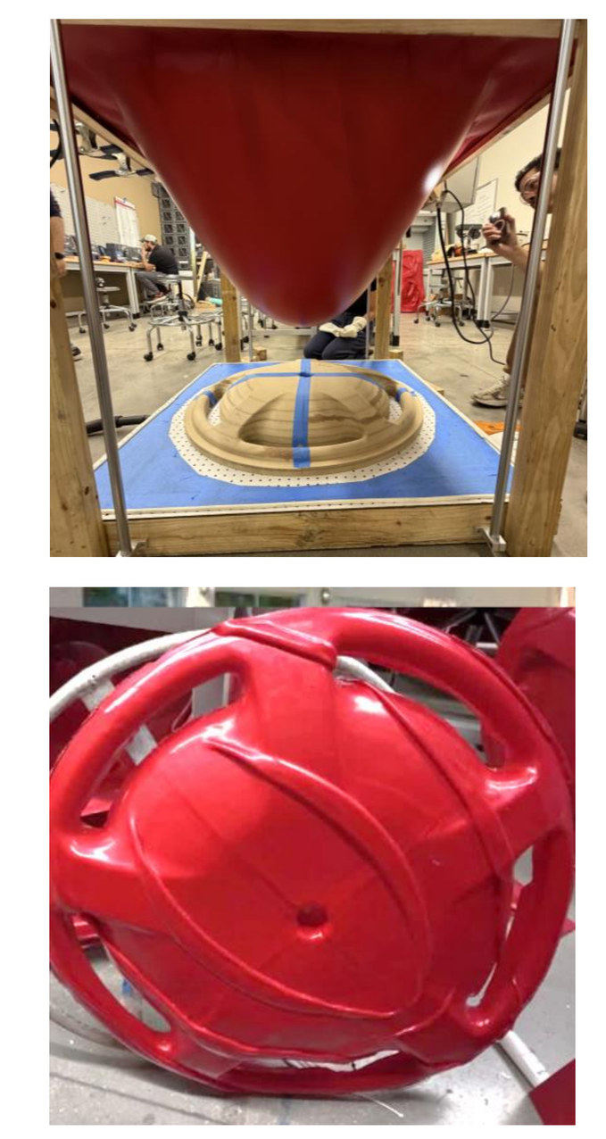


TEST 2
Added aluminum hotplate to heating elements

Plastic still heated unevenly

TEST 3
New larger heating element array was wired and installed

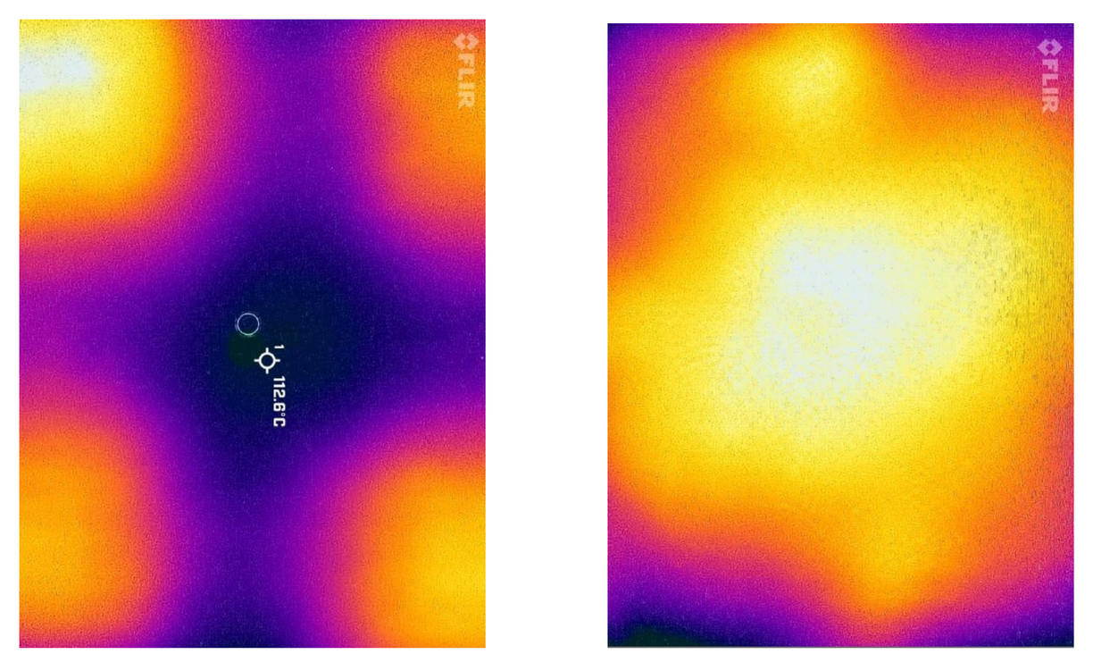
Proper heating
Improper vacuum seal



TEST 4
Vacuum leaks isolated and sealed

Held under heat too long

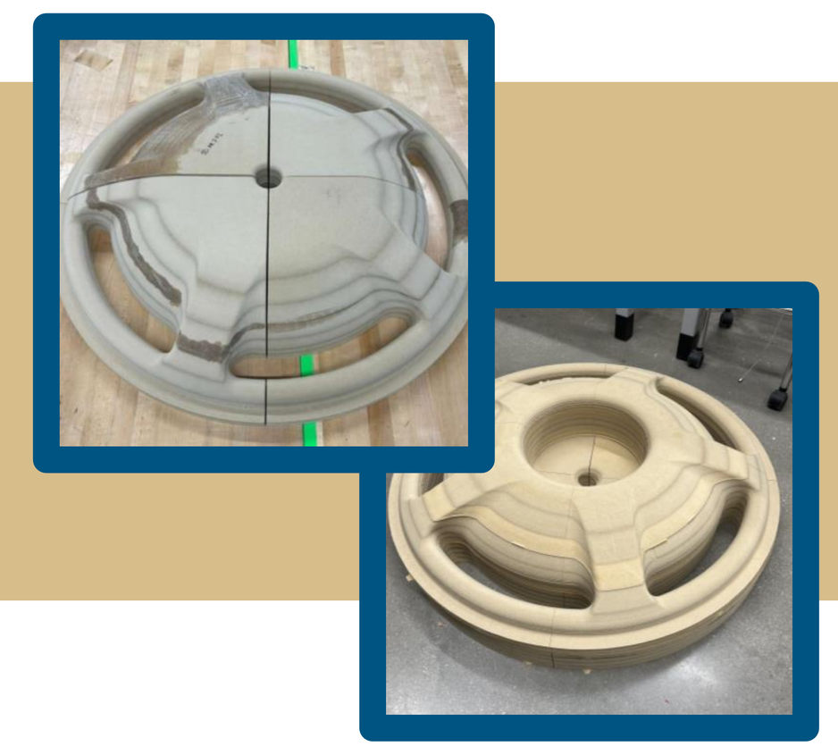
Thermal Imaging



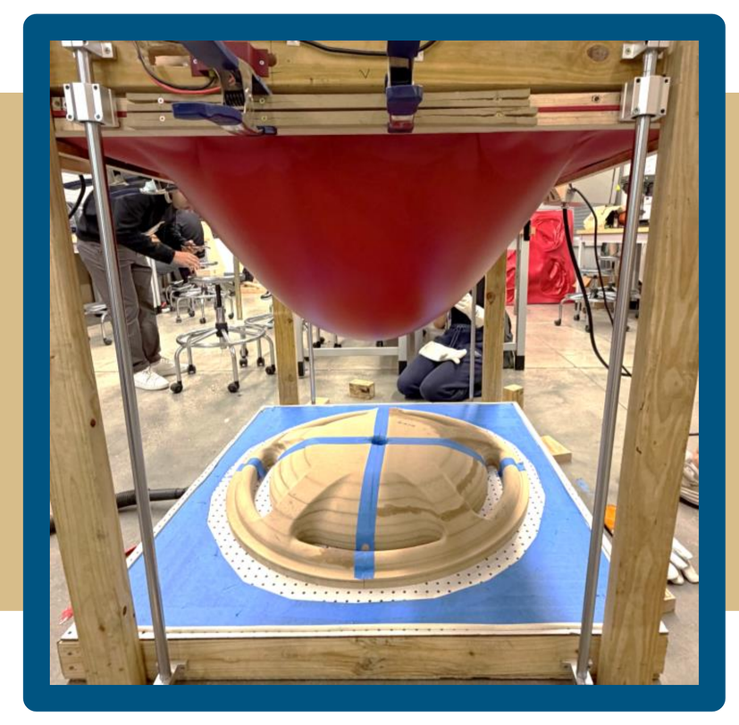
Thermal gradient on the aluminum sheet before and after the heating system upgrades

FABRICATION

I. Forming Process Machine



A top and bottom buck is machined out of MDF and is used to form all six buoys



Marine grade HDPE is heated to its glass transition temperature (130°C-160°C)

Heated plastic is lowered over the mold on a vacuum table

The HDPE is then cut and processed

II. Foam Filling

Each half of the buoy is filled with a two-part expanding foam

III. Plastic Welding

The two halves are then plastic welded together to create the final buoy

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HUNT HUNT

DEVELOPMENT PROCESS

I. Identifying Customer Needs

Market Research

Interviews

Self Tested

- Similar market products
- Material research papers
- Diver-below buoy patents
- Ergonomics
- Stability of system
- Set-up process

II. Established Design Specifications

Longevity: 3–5-year service life in outdoor aquatic environments

Buoyancy: Comparable stability and floatation performance to the buoys currently in use

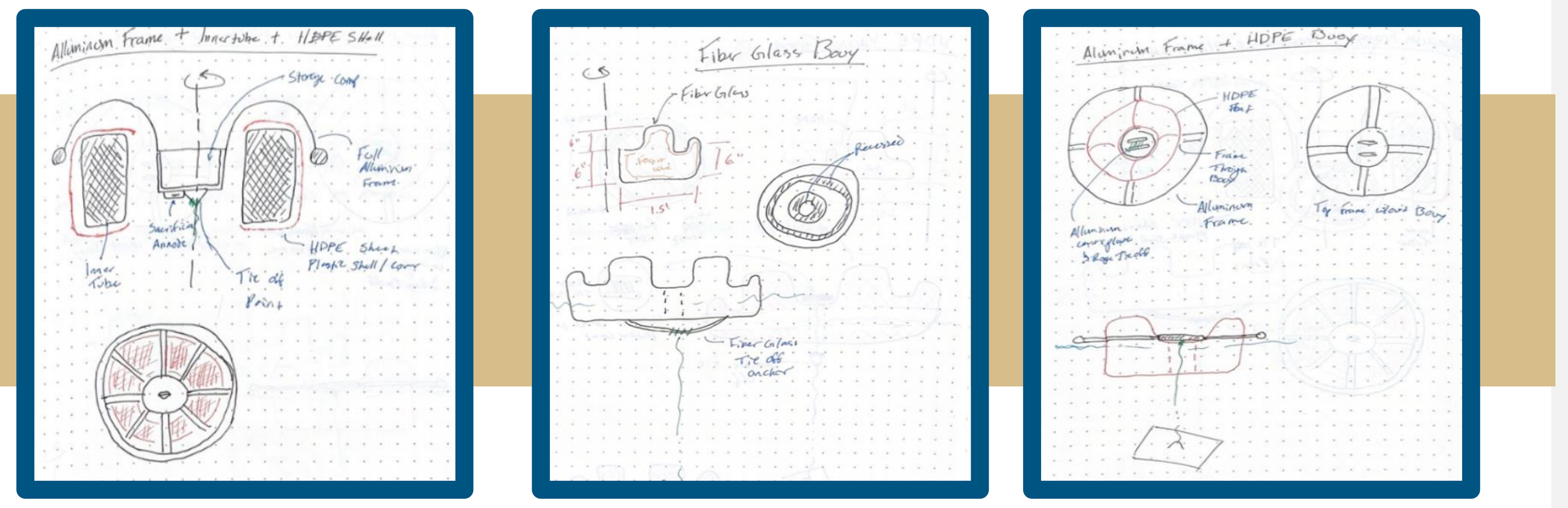
Durability: Resistant to marine wear-and-tear and UV degradation

Diver Stability: Supports 3-4 divers

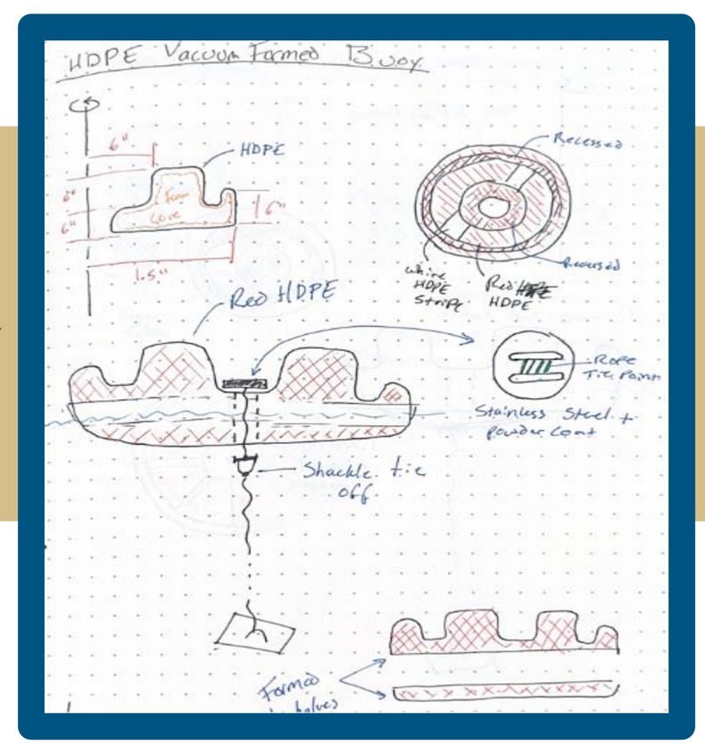
Storage: Securely holds extra diving weights for diving instructors to quickly access

Low Maintenance: Maintenance cycles and labor requirements are equal to or lower than the in-use buoy

III/IV. Concept Generation & Selection

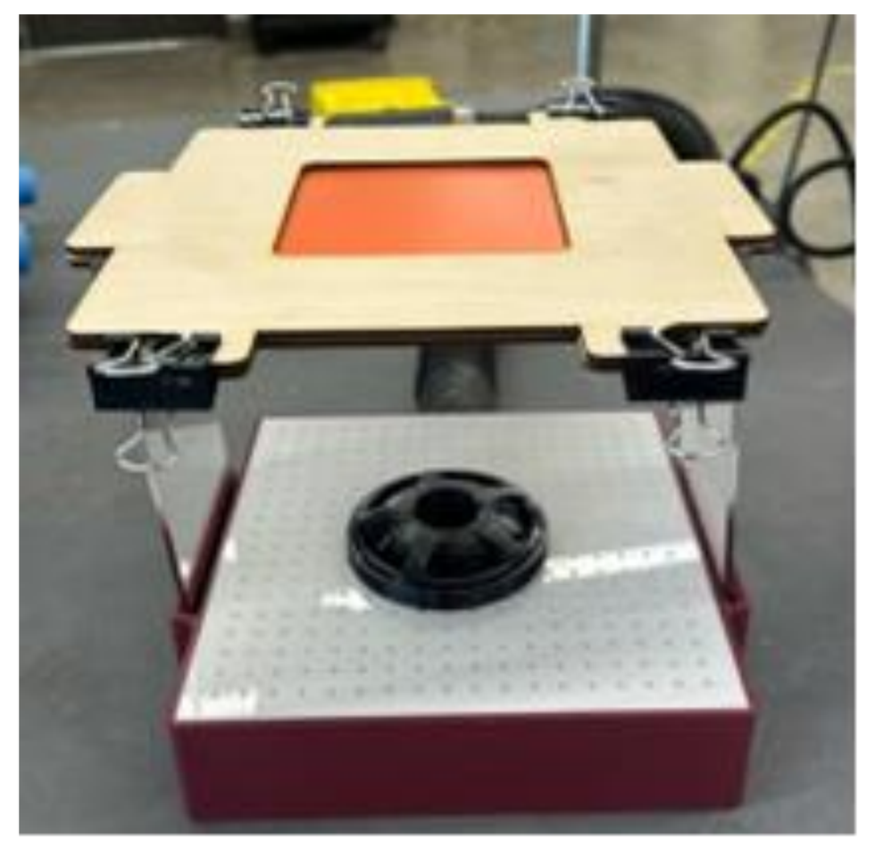


Selection Criteria	(Reference) Aluminum Frame	Aluminum Frame +Anode	Hollow Handles	Aluminum & HDPE	Fiberglass Composite Shell	HDPES Formed shell
Longevity	0	1	1	1	1	1
Buoyancy	0	0	1	1	1	1
Durability	0	1	1	1	1	1
Storage	0	1	1	1	1	1
Diver Stability	0	1	1	1	1	1
Serviceability	0	0	-1	-1	-1	-1
Support 3-5 Divers	0	1	1	1	0	0
Visibility	0	0	1	1	1	1
Ease of use/ergonomics	0	0	0	0	0	0
Manufacturability	0	0	-1	0	0	1
Environmental Compatibility	0	0	0	0	0	0
Ease of Setup	0	0	0	0	1	1
Sums +'s	0	5	7	7	7	8
Sums 0's	0	7	3	4	4	3
Sums -'s	0	-1	-2	-1	-1	-1
Net Score	0	4	5	6	6	7
Ranking	9	5	4	3	2	1



V. Scaled Fabrication Testing

Scaled Test



FMEA

Failure mode and Effects analysis

Design Item or Process Function Requirements	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Potential Cause(s) / Mechanism(s) of Failure	Occ	Current Design or Process Controls	Det	RPN
Mid-seam weld joins halves	Seam weld failure / internal leak	structural separation; loss of buoyancy	10	Filler contamination; poor heat control; poor weld control	4	Make Welding SOP, Visual inspection, and Scaled peel/bend weld test every 3 feet.	3	120
Handles for diver support	Handle tear-out	Injury risk; damage to buoy	10	insufficient foam filling (air gaps)	4	Handles are filled separately from the core and inspected before the 2 shell halves are joined, also a weight increase comparison	2	80
Structural support Foam core	Foam waterlogging / poor closed-cell	Increased weight; mildew	7	poor sealing; open-cell foam used	1	Verify the 2-part expanding foam is closed-cell before use	1	7
Vacuum-formed shell thickness	Excessive draw-thinning (thin corners)	Local dents, crack initiation	6	Deep draws; sharp radii; poor heating profile	3	Making an SOP for vacuum forming and measuring thickness with calipers before	2	36
Foam expansion during fill	Over-pressurization causing shell	Warped shell; leaks at seams	5	No vent/overflow; excessive mix; high ambient temp	3	Scaled foam expansion test before each pour	2	30
Anker to platform	anker point failure under	Buoy loss; hazard to other craft	5	cyclic fatigue; stress concentration	2	proof-load pull to 2× design load (30–60 s)	2	20