



TECHNICAL NOTE 100-3

Syntactic Foam Material Selection and Depth Rating

INTRODUCTION

The selection of syntactic foam buoyancy materials requires making informed judgements about depth, density, and performance over time. To assist in this process, the following design procedure is suggested. Note that many of the concepts used herein were first introduced in Technical Note 100-2, "Predicting Hydrostatic Performance of Syntactic Foam."

STATE THE MISSION

The "Mission Statement" is intended to answer basic questions about the application, such as depth, time at depth, and nature of the payload from which the desired *safety factor* can be inferred. The safety factor, or C/P ratio (crush pressure divided by service pressure), is the single most important consideration in rating syntactic foam. Figure 1 illustrates rating practice that is typical for the offshore industry.

Figure 1 TYPICAL SYNTACTIC FOAM DEPTH RATING PRACTICE

Safety Factor (C/P Ratio)	Service/Crush Depth (P/C Ratio)	Nature of Application
1.0 - 1.25	0.80 - 1.00	Non-critical/short term: inexpensive or expendable instruments, one-time use applications.
1.25 - 1.50	0.65 - 0.80	General purpose: unmanned subs, ROVs, exploration risers, ordinary floats and buoys.
1.50 - 2.00	0.50 - 0.65	Critical/long term: Manned subs, production risers, long-lived floats and buoys.

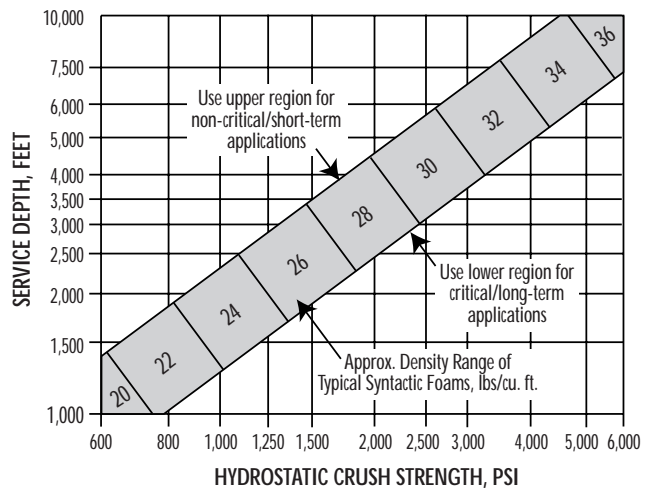
DETERMINE SYNTACTIC FOAM DENSITY

Since the strength of syntactic foam is proportional to its density, higher safety factors will require heavier materials than will lesser safety factors. Figure 2 illustrates the approximate relationships between syntactic foam density, hydrostatic crush strength, and service depth. The shaded band represents the range of commonly available macrosphere-type syntactic foams (for a discussion of "solid" microspheres-type materials, see Technical Bulletin 125). The width of the shaded band spans C/P ratios from 1.00 to 2.00.

Notes on Reading Figure 2

Figure 2 can be read either vertically or horizontally. For example, say analysis of a general-purpose mission indicates a minimum C/P ratio

Figure 2 STRENGTH vs. DENSITY OF TYPICAL SYNTACTIC FOAMS



of 1.33. This means that a buoy for duty at 3,000 ft (1,332 psi) should be made of syntactic foam with a crush strength of at least 1,775 psi. Reading vertically, we see that 27.0 pcf is the recommended density. Reading horizontally across from 3,000 feet, we find that a range of densities from 26.0 to 28.0 pcf might be used, depending on mission requirements. The crush strength of 26.0 pcf material is about 1,500 psi, while that of 28.0 pcf is about 2,000 psi. The section below can be used to compare the performance of the various materials options. It will be found, for instance, that the 26.0 pcf material will absorb water at three times the rate of 28.0 pcf material at 3,000 feet (W = 9.0% vs. 3.0% after one year at depth).

ESTIMATE LONG-TERM PERFORMANCE

Using the principles explained in Technical Note 100-2, it is possible to estimate the amount of buoyancy loss due to weight gain or water absorption during the design life of the system. The following is an abbreviation of equations [2] and [3] from Technical Note 100-2:

$$W = R (\text{Log NH})$$

Where:

- W = Percent weight gain, %.
- R = $0.25\{1-(P/C)\}$.
- P = Service pressure, psi.
- C = Crush strength, psi.
- N = Number of cycles to pressure P.
- H = Total no. of hours at pressure P.

CALCULATE TOTAL BUOYANCY REQUIREMENT

The total buoyancy requirement is the basic nominal amount of buoyancy plus several additive factors, as shown below:

$$BT = B1 + B2 + B3 + B4$$

Where:

- BT = Total buoyancy requirement, Lbs.
- B1 = Basic amount of buoyancy (usually the in-water weight of the payload).
- B2 = Elastic loss due to compression of the syntactic foam (Equation [1] in Technical Note 100-2, or use 1.0% of B1.)
- B3 = Permanent loss due to water absorption (Equations [2] and [3] in Technical Note 100-2, or see the previous section).
- B4 = Extra buoyancy that may be required to offset tolerances and unknowns, future payload increases, etc.

DESIGN THE BUOY

You are now ready to rough out the design of the buoy, using relationships charted in Figure 3. This is often an iterative process, requiring reappraisal and refinement of many design factors. For guidance in specifying, purchasing, and testing syntactic foam products, see Technical Note 100-4.

Figure 3 BUOY DESIGN FORMULAS

Units	English	Metric
D = Density (specific weight)	lbs/cu ft	g/cc
B = Buoyancy (net upward force)	lbs.	kg
Bf = Buoyancy in Fresh Water	lbs.	kg
Bs = Buoyancy in Sea Water	lbs.	kg
W = Weight of Float in Air	lbs.	kg
V = Volume of Float	cu. ft.	liters
G = Density of Liquid (see Note 1)	lbs/cu ft	g/cc

Known	To Find	
D, V	$B = V(G-D)$	$W = DV$
W, V	$B = GV-W$	$D = W/V$
W, D	$B = (GW/D)-W$	$V = W/D$
D, B	$V = B/(G-D)$	$W = BD/(G-D)$
V, B	$W = GV-B$	$D = (GV-B)/V$
W, B	$V = (B+W)/G$	$D = GW/(B+W)$
W, Bf	$Bs = 1.026 Bf + 0.026W$	
W, Bs	$Bf = (Bs/1.026) - 0.025W$	

Notes

- If B = Bf, use G = 62.4 lbs/cu. ft. (1.000 g/cc).
If B = Bs, use G = 64.0 lbs/cu. ft. (1.026 g/cc).
- For any given value of V and different values of D, B+W = CONSTANT.

CONSULT THE EXPERTS

Cuming Corporation is the world's leading manufacturer of syntactic foam, and our engineers are the most experienced buoy designers in the business. We are constantly testing materials and comparing their performance to the predictive methods described in these Technical Notes. Requests for quotes and design assistance are always answered promptly. Contact our Customer Service Department today for your free consultation.



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