Experimental Diving Unit Report
6-49

THE DESIGN OF A SELECTOR DISC FOR DETERMINING THE AMOUNT OF OXYGEN THAT MUST BE ADDED TO A BOTTLE OF HELIUM IN ORDER TO OBTAIN A CERTAIN DESIRED PERCENTAGE OF HELIUM OXYGEN MIXTURE

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OBJECT

To design a compact, selector disc for quickly determining the amount of oxygen that must be added to a bottle of helium at a known pressure in order to obtain a certain desired percentage of helium-oxygen mixture.

SUMMARY

(1) The formula $\text{Initial Pressure} \times 100 = \text{Final Pressure} \times \frac{100 - 02\% \text{ Desired}}{100 - 02\% \text{ Desired}}$ has previously been used for calculating the information necessary in mixing desired percentages of helium-oxygen from helium bottles of known pressures.

(2) This information has been arranged on a circular selector disc for speed, accuracy and convenience.

(3) It supplies the information for producing mixtures of from 10 to 21% of oxygen from bottles containing 800 to 1190 psi of helium.

(4) The maximum depths for which these percentages of helium-oxygen can be used have been calculated on the basis of 2.3 atmospheres of effective oxygen as the maximum allowable. These figures are given in tabular form on the face of the selector disc.

(5) The formula employed is shown on the face of the disc and can be used in calculations for mixtures not covered by the range of the disc.

BACKGROUND

Since the early days of helium-oxygen diving in the U.S. Navy the formula, $\text{Initial Pressure} \times 100 = \text{Final Pressure} \times \frac{100 - 02\% \text{ Desired}}{100 - 02\% \text{ Desired}}$ Pressure has been used in preparing helium-oxygen mixtures of varying percentages. This formula has been used in making the calculations and obtaining the data presented on the proposed disc.

EXAMPLE: If it is desired to make a 15% mixture of helium-oxygen from a bottle of helium at a pressure of 1000 pounds, it will be determined that enough oxygen must be bled into the helium bottle to raise the pressure to 1176 pounds.

$$\frac{1000 \times 100}{100 - 15\%} = 1176 \text{ pounds final pressure.}$$
A graph is in existence which can be used in obtaining approximately the same data. However, selector discs are read more easily and with less chance of error than are graphs. They are also more conveniently carried about.

The design of this disc was undertaken to eliminate the necessity of mathematically computing each individual bottle and the possible errors resulting from these calculations.

DESCRIPTION

1) The selector disc is composed of two superimposed discs, a main base disc (figure 1) and a front disc (figure 2).

2) The final pressures to be sought for all mixtures are printed on the face of the base or main disc. The original pressures of the helium bottles are printed along the periphery of the main disc and vary in 10 pounds steps from 800 to 1190 pounds. These pressures cover the range most frequently encountered in helium bottles after they have been split.

Twelve figures are printed beneath each helium pressure and represent the final pressures to be expected for percentages from 21% to 10%. (From periphery toward the center).

3) The front or rotating disc is somewhat smaller than the main disc, permitting the original pressures of the helium bottles to be read when the disc are superimposed.

4) A slot in the front disc, permits only one column of figures to be read at one time. The percentages corresponding to the proper final pressures are printed to the left of the slot.
(5) In addition to the above information the front disc provides the following:

(a) The formula which may be used for mixing any bottle whose pressure is out of the range of the disc.

(b) The maximum depth (gauge) for which each percentage of mixture can be used. This has been determined on the basis of 2.3 atmospheres of effective oxygen, allowable:

\[
33 \text{ feet} = 1 \text{ atmosphere} \\
33 \times 2.3 = 75.9 \text{ feet, effective oxygen} \\
75.9 \times \frac{100}{02} = \text{Depth absolute} \\
\text{Depth absolute} - 33 \text{ feet} = \text{Depth (gauge)}.
\]

**DISCUSSION**

No change has been made in the formula used for computing these figures, for it is theoretically mathematically correct.

In mixing oxygen and helium the two bottles are connected by means of a copper tube. The oxygen being at a higher pressure is forced into the helium bottle. As a result of the gaseous expansion and compression which takes place, the oxygen bottle cools and the helium bottle becomes warm. Therefore, the pressure in the helium bottle is higher at this moment than it would be after it returns to room temperature. On a basis of pressure alone oxygen and helium can be accurately mixed for desired percentages only if there is no temperature change. However, in our case the pressure of the mixture on completion of the mixing process is misleading since it elevates with the temperature rise and later drops as the bottle cools. Hence, it is reasonable to assume that upon cooling there would be a deficiency of oxygen. This has been the case. It has been found experimentally that it is necessary on a basis of pressures to mix for approximately 1% more oxygen than desired.
EXAMPLE

If it is desired to make a 15% helium-oxygen mixture from a bottle of helium at a pressure of 1000 pounds, the rotating disc is turned so that the slot exposed the column of figures under the 1000 pound heading (figure 3). Practical experience having taught us that it is best to mix for 1% higher, we look opposite 16% and read 1190 pounds. This tells us that enough oxygen must be "bled" into the helium bottle to raise the pressure to 1190 pounds.

It will be found that more accurate results will be obtained if this bleeding is done gradually, about 70 pounds per minute, rather than in short bursts as advised in the present diving manual. This correction is being made in the new diving manual.

The selector disc offers the following advantages:

ACCURACY: The disc eliminates the necessity for individually computing each bottle and the possibility of error involved in this procedure.

CONVENIENCE: This disc is reasonably compact and eliminates the inconvenience of obtaining pencils and writing pads for individual calculations.

SPEED: The saving in time is quite obvious, for by using the disc the final pressure desired can be found in a few seconds.

SAFETY: A rapid check can be made by consulting the table for maximum diving depth allowed with each mixture.

The present form of the disc is experimental. If produced for general use, it should be made of grease and water resistant paper or heat resistant plastic.
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**ABSTRACT**

To design a compact, selector disc for quickly determining the amount of oxygen that must be added to a bottle of helium at a known pressure in order to obtain a certain desired percentage of helium-oxygen mixture.
<table>
<thead>
<tr>
<th>KEY WORDS</th>
<th>LINK A</th>
<th>LINK B</th>
<th>LINK C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diving</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Gas Mixing</td>
<td></td>
<td></td>
<td></td>
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</tbody>
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