15 March 1983

ERRATUM

NEDU Report 1-83: Computer Algorithms Used in Computing the MK 15/16 Constant 0.7 ATA Oxygen Partial Pressure Decompression Tables.

After publication and distribution, an error was found in Version 1.1 of Subroutine FRSP7 which will cause small underestimates in no-decompression time and which will (in certain instances) compute first stop depths one depth increment deeper than necessary. (The program computes 0 min stop times at these too deep first stops so the resulting decompression profiles are correct).

All holders of the above report should make the following changes and substitutions to the original:

1. Replace pages 40/41 and B4-1 thru B4-4 (Annex B4) with the attached pages. Note that the replacement pages are all coded ERR 1.0 in the lower right hand corner. Subroutine FRSP7 is now Version 1.2.

2. Make a pen and ink change to Fig. 9 (page 30). Change the no-decompression time at 110 FSW from 23 to 24 min.

All other decompression profiles and Model Parameter Printouts remain correct for Version 1.2 of Subroutine FRSP7.
Exponential Update Procedure
(Lines 240 - 245)

This procedure updates the tissue for a linear ascent or descent. After
the update is complete, control is transferred back to the beginning of the
loop until all NTISS tissues have been done. After all tissues have been
updated, control drops through to the procedure which computes the Instantan-
eous Ascent Depth.

Instantaneous Ascent Depth Computation Procedure
(Lines 273 - 284)

This procedure is identical to the one used in the E-L Version of UPDT7.

Subroutine FRSP7

This subroutine finds the depth of the first stop for a specified ascent
rate. The depth of the first stop is passed back to the main program as an
argument of the subroutine (DFS), all other data is passed in the three
common blocks PARAM, BLDVL and MDATA. The subroutine uses the Instantaneous
Ascent Depth (IAD) calculated by Subroutine UPDT7 as a first approximation of
the first stop depth. A trial update at the specified rate is performed
first to DINC deeper than the IAD then if all ascent criteria are met at
DINC+IAD to IAD itself. Depending on the rate of ascent and the initial
tissue tensions the tissues may saturate or desaturate during the trial
ascent and may have taken up excess gas (in which case the new IAD after
ascent will have increased), offfgassed sufficiently to go shallower (in which
case the new IAD will have decreased) or still have just enough gas on board
to require a stop at IAD (in which case the IAD will not have changed).
Depending on whether the IAD has increased or decreased after the trial
ascent, the first stop depth estimate is increased or decreased in increments
of the stop depth increment (DINC) until the IAD before and after ascent are
the same and are in fact equal to the depth which has just been ascended to.

Initialization Procedure
(Lines 105 - 119)

The depth of the first stop (DFS) is initially set to the current depth
and if the current depth is equal to or shallower than the IAD, CDEPTH
becomes the first stop depth. This precaution is necessary for two reasons.
The first is that if the DX option is used for an ascent one could end up at
a depth shallower than the IAD. If the DX option were not specified for the
next ascent, the subroutine would attempt to descend to the IAD causing a
negative descent time to be computed. Rather than have that happen, a stop
will simply be taken at CDEPTH until ascent is possible. The second
situation will occur if a 0 min stop is taken at a decompression stop during
ascent (as in changing breathing gases) in which case the current depth will
be equal to the IAD. In this case (unless precautions are taken) a trial
descent would be performed to DINC+IAD causing the tissue tensions to increase and an anomalous stop to be taken at DINC+IAD. In the auto-decompression mode one can never go too shallow so the depth of the first stop will never be deeper than the current depth. Line 110 ensures this is always the case.

In lines 115 to 118 the logical variable LASTIT is initialized to "false" and the current tissue tensions and IAD stored temporarily because they will be changed when Subroutine UPDT7 is called to do the trial ascent.

Depth of First Stop Iteration Loop
(Lines 133 - 191)

The variable MIND is set initially to the IAD and in lines 137-143 a trial update is done from the current depth to MIND+DINC. This must be done because the definitions of the ascent criteria requires that they be met DINC deeper than a given depth before ascent to that depth is possible. In lines 144 and 145 the tissue tensions and IAD are restored to their original values. If after ascent to MIND+DINC the IAD has increased, control is transferred by line 152 to line 161 where it will drop through to line 173. If the IAD has remained the same or decreased during the first trial ascent lines 153-155 do another trial ascent to IAD. If the new IAD equals MIND (the value of IAD before ascent) then line 161 transfers control to Statement 50 (line 188) where the value of the depth of the first stop (DFS) is set to MIND and the subroutine exited.

If IAD and MIND are not equal after the trial ascent then control goes to line 173. Since additional tissue saturation or desaturation takes place during ascent it is unlikely that MIND and IAD will be equal the first time through the loop. The usual sequence of events is that the value of MIND is systematically increased or decreased and by the second iteration the value of IAD doesn't change after the trial update and the loop is exited at line 161 with MIND containing the value of the depth of the first stop. In a very few cases, however, the IAD may increase on one pass through the loop and decrease on the next. This occurs when a tissue is still saturating during ascent. On the first trial update all tissue tensions will be less than their maximum permissible values contained in array M and the new IAD decreases by one depth increment after the trial update to the original value of IAD. The next time through the loop the trial update will be to the new value of IAD. If a tissue was saturating during ascent it may have taken up enough additional gas during the additional ascent to the new IAD to just exceed its maximum permissible value. Thus, when the next trial update is done the value of IAD will decrease by one depth increment. This oscillation will continue indefinitely because the tissue will have a tension just below its maximum permissible value at the deeper trial stop and just above it at the shallower trial stop. Since the ascent criteria state that once the maximum permissible tissue tension has been reached at a given depth that ascent to the next shallower depth increment is allowed the depth of the first stop is taken at the shallower of the two depths, and assigned to MIND.

Once the depth of the first stop has been found the IAD is restored to its original value, the value of the integer MIND is assigned to the real variable DFS and the subroutine returns control to the main program (lines 188-191).
SUBROUTINE FRSP7(DFS), 01 MAR 83 VER 1.2

FINDS DEPTH OF FIRST STOP (DFS), TRIAL STOP DEPTH (MIND)
INITIALLY SET TO CURRENT INSTANTANEOUS ASCENT DEPTH (IAD).
TRIAL ASCENT TO "MIND" IS DONE TO SEE IF "IAD" CHANGES DURING
ASCENT. IF "IAD" CHANGES A NEW TRIAL ASCENT FROM "CDEPTH" TO THE
NEW "IAD" IS DONE. ITERATION CONTINUES UNTIL THE "IAD" AFTER
ASCENT AND "MIND" ARE EQUAL.

DEPTH OF FIRST STOP WILL NEVER BE DEEPER THAN THE CURRENT
DEPTH. IF ASCENTS ALWAYS ACCOMPANIED BY APPROPRIATE DECOMPRESSION
NO PROBLEMS WILL OCCUR. HOWEVER, IF AN ASCENT IS TAKEN WITHOUT
DECOMPRESSION STOPS THEN A FIRST STOP DEPTH SOUGHT, THE "IAD" MAY
BE DEEPER THAN THE CURRENT DEPTH. IN THESE CASES THE FIRST STOP
DEPTH WILL BE THE CURRENT DEPTH.

This subroutine is designed to calculate the depth of the first stop during decompression after an ascent. It iterates through potential stop depths, initially set to the current instantaneous ascent depth, to determine if a new trial ascent changes the ascent depth. The process continues until the ascent depth and the selected stop depth are equal. The first stop depth will never be deeper than the current depth, unless an ascent without decompression stops is attempted, in which case the first stop depth may exceed the current depth. The subroutine is written by CDR Edward D. Thalmann (MC) USN and is associated with the U.S. Navy Experimental Diving Unit in Panama City, Florida, Unit 32407.

Variables used in the subroutine include:
- AMBRO2: Ambient-arterial oxygen gradient (FSW)
- CDEPTH: Current depth (FSW or MSU)
- CF: Metric conversion factor
- CP02: Constant partial pressure of O2?
- DC: Depth change (FSW or MSU)
- DFS: Depth of first stop (FSW or MSU)
- DINC: Stop depth increments (FSW or MSU)
- FH2: Inert gas fraction
- HLFTM: Compartment halftime (min)
- IAD: Instantaneous ascent depth (FSW or MSU)
- IADTMP: Variable to temporarily store current value of "IAD".
- LASTIT: Last time through iteration loop?
- M: Compartment maximum gas tension array (FSW)
- MIND: Trial first stop depth (FSW or MSU)
- NTISS: Number of halftime compartments (9 max.)
- P: Compartment gas tension array (FSW)
- PCO2: Arterial CO2 partial pressure (FSW)
- PBVP: Gas phase overpressure (FSW)
- PH2O: Partial pressure of water vapor (FSW)
- PO2: Inspired oxygen partial pressure (ATA)

This code is part of a larger system for diving decompression calculations, ensuring the safety of divers by managing the transition between depths and avoiding excessive pressures.
C PVC02 VENOUS CO2 PARTIAL PRESSURE (FSW)
C PV02 VENOUS O2 PARTIAL PRESSURE (FSW)
C RATE RATE OF TRAVEL DURING DEPTH CHANGE (FSW OR MSW/MIN)
C SDR SATURATION-DESATURATION HALFTIME RATIO
C TC TIME CHANGE DURING ASCENT (MIN)
interpreted text
C TP ARRAY TO TEMPORARILY STORE COMPARTMENT GAS TENSIONS
C
NOTE: FOR PARTIAL PRESSURES WHICH ARE IN FSW, 33 FSW=1 ATA.
C
C**********************************************************************
C INITIALIZATION PROCEDURE
C**********************************************************************
0106 DFS=CDEPTH
0107 IF(INT(CDEPTH) .LE. IAD) RETURN
0108 INITIALIZE "LAST ITERATION" SWITCH. SAVE TISSUE TENSIONS AND "IAD" TEMPORARILY.
0111 DO 20 I=1,NTISS
0112 TP(I)=P(I)
0115 IADTMP=IAD

B4-2
ERR 1.0
C***********************************************************************
c
C END OF INITIALIZATION
c
C***********************************************************************
c
C DEPTH OF FIRST STOP ITERATION LOOP
C
ALL EXITS GO TO STATEMENT #50
C
C***********************************************************************
C TRY FIRST STOP DEPTH AS "IAD". DEFINITION OF ASCENT CRITERIA
REQUIRES THEY BE MET "DINC" DEEPER THAN FINAL FIRST STOP DEPTH.
C
MIND=IAD
DC=MIND-CDEPTH+DINC
TC=DC/RATE
C
SUBROUTINE UPDT7 WILL COMPUTE NEW "IAD" AFTER TRIAL ASCENT.
C REESTABLISH TISSUE TENSIONS AFTER CALLING SUBROUTINE UPDT7.
C
CALL UPDT7
DO 32 I=1,NTISS
P(I)=TP(I)
C IF "IAD" HASN'T CHANGED OR HAS DECREASED DURING TRIAL ASCENT TO
"DINC" THEN ASCENT TO "MIND" MAY BE POSSIBLE WITHOUT
VIOLATING THE ASCENT CRITERIA. GIVE IT A TRY. REESTABLISH TISSUE
TENSIONS WHEN DONE.
IF(IAD .GT. MIND) GO TO 42
DC=MIND-CDEPTH
TC=DC/RATE
CALL UPDT7
DO 40 I=1,NTISS
P(I)=TP(I)
C IF NEW "IAD" AND "MIND" EQUAL AFTER TRIAL ASCENT, WE'RE DONE.
C
IF(IAD.EQ.MIND) GO TO 50
C
C IF NEW "IAD" IS SHALLOWER THAN "MIND" SET "LASTIT" TO TRUE. THIS
WILL STOP THE ITERATION IF "IAD" BECOMES GREATER THAN "MIND" THE
NEXT TIME AROUND. THIS WILL PREVENT GETTING STUCK IN THE LOOP IF
THERE IS A TISSUE STILL SATURATING AT "MIND" IN WHICH CASE "IAD"
WILL NEVER EQUAL "MIND" BUT WILL OSCILLATE ONE DEPTH INCREMENT
DEEPER AND SHALLOWER ON SUCCESSIVE ITERATIONS. IN THESE CASES THE
FIRST STOP DEPTH IS THE FIRST VALUE OF "MIND" WHICH CAUSES "IAD"
TO INCREASE IN VALUE AFTER IT HAD DECREASED ON THE PREVIOUS
ITERATION.
IF(IAD.LT.MIND) LASTIT=.TRUE.
IF(IAD.GT.MIND .AND. LASTIT) GO TO 50
C
SET UP FOR ASCENT TO NEW "IAD".
C
GO TO 30

ERR 1.0
C***********************************************************************
C END OF ITERATION LOOP
C***********************************************************************

REESTABLISH "IAD". DEPTH OF FIRST STOP IS "MIND".

IAD=IADTMP
DFS=MIND
RETURN
END