PLANNING FOR THE *WORST*

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1993

In aviation we always plan and train for worst case conditions. For example; dynamic engine failure *both before and after* V-1, failure of flaps to extend, resulting in a no-flap landing, a complete hydraulic failure, resulting in a manual reversion landing without the benefit of nose wheel steering and engine reverse thrust, relying on emergency brakes without anti-skid to stop the aircraft. Regardless of how remote each possibility is, the flight crew must address and train for the *worst case condition* whatever that my be.

One subject that is not receiving adequate attention is, oxygen planning for the international flight crew. If nothing else is accomplished in this overview, we would like to increase international flight crew member awareness of the "worst case scenario" as defined by F.A.A. ETOPS requirements and offer some suggestions for coping with an oxygen emergency.

Planning for an oxygen emergency is, in all probability, the most complex and critical situation an international pilot must face. Certainly the myriad details, flight planning, ground handling arrangements, weather, slot times, air traffic control, alternate airports and the ever present difficulty with the language spoken. However, there is nothing that will spoil your day as much as a rotor burst that penetrates the aircraft pressure vessel.

The "worst case scenario" is defined as an engine rotor burst where engine debris penetrates the pressure vessel and depressurizes the aircraft. You are suddenly a single engine unpressurized aircraft. You must now get your aircraft, passengers and flight crew safely and expeditiously to the nearest suitable airport and land. Let's look at some of the information and requirements that need to be addressed in coping with this situation.

The prudent flight crew always calculates an equal time point (ETP) for each flight. The (ETP) defines the point over water or precipitous terrain where it is equal time en-route to either reverse course and return to a suitable airport or continue flight to a suitable airport for landing. In the event of an emergency prior to reaching the ETP the flight crew will return to the nearest diversion airport, if the emergency occurs after passing the ETP, the flight crew would continue to their "coast in" diversion airport.

When your aircraft was certified, the manufacturer or completion center had to address the "worst case scenario" at the ETP in order to insure an adequate supply of oxygen for crew and passengers to safely continue flight after experiencing a decompression. For example, system design for the Gulfstream family of aircraft considered a flight from San Francisco to Honolulu against a 90 knot headwind. This was deemed to be the worst case for the longest over water flight *necessary*. You can of course find longer over water legs but there are alternate routes to deal with these situations.

Gulfstream calculated an ETP using the above conditions (SFO-HNL at -90 kts), at the ETP they simulated an explosive decompression, executed an emergency descent to 10,000 feet and calculated the fuel necessary to either continue to HNL or return to SFO at 10,000 feet. To their dismay they discovered that they did not have adequate fuel to reach either airport, this is our proverbial "wet footprint" scenario. In order to safely continue the flight, the aircraft had to climb to a higher altitude to increase specific range (SR), where the fuel on-board was equal to the fuel required to reach the diversion alternate and land with necessary fuel reserve. When an altitude was selected where the above fuel requirements were satisfied, the oxygen requirements for the crew and passengers at that altitude had to be calculated.

Oxygen flow rates for crew, passengers, and duration of flight had to be considered to determine the size and number of bottles required to provide an adequate oxygen supply. The resulting oxygen requirement became the basis for a supplemental type certificate (STC) for the oxygen system on the particular aircraft.

As aircraft range increased, which meant more fuel on board at the ETP, the aircraft could tolerate a lower flight level, thereby reducing the oxygen requirements. An example of this is the Gulfstream series of aircraft. The GII has 11,495 liters of oxygen, the GIII has 7,870 liters and the GIV has 7,930 liters of oxygen available. This is an excellent example of the "balance" between fuel and oxygen and the ability to "trade" one resource for the other. As aircraft range increased (more fuel) the oxygen requirement decreased. (Fuel "traded" for oxygen requirement)

This brings up another situation or condition flight crews must address. With an increase in aircraft range you have the ability to leave from an inland departure point, over-fly San Francisco outbound and, if you are faced with the proverbial "worst case scenario", you may not have the necessary oxygen resource to safely complete the flight. Remember, you have less oxygen because you had more fuel (range) and now you have expended some of that fuel (range) on the overland portion of your flight, don't get caught in this trap-- Know *BEFORE* You Go.

With the above information as a starting point let's take a flight out to the ETP and experience an engine rotor burst with debris that penetrates our pressure vessel. We are now at the most critical point in the flight and are suddenly a single engine, unpressurized aircraft. We must execute an emergency descent to 10,000 feet, check passenger well being, and quickly determine if we have enough fuel aboard at that point to safely continue, if we do, our emergency is over! This is indeed our lucky day. However, if we do not have an adequate supply of fuel we must execute a climb to increase our specific range.

Here are some of the questions that will require your immediate attention, the longer you wait the more critical your situation can become!

- How much fuel do we have on board?
- How far is it to the nearest suitable airport?
- Is fuel on board sufficient to get us overhead the airport with reserve?

IF NOT:

- What altitude will it take to assure us that the fuel on board is adequate, including reserves?

At this aircraft weight, at this altitude, what will our ground speed and estimated time en route (ETE) be? *Note: Using MSR or LRC cruise mode the Mach number and TAS decrease with a decrease in aircraft weight. This calculation is a "moving" target and must be continually updated for accuracy.*

- How many liters of "useable" oxygen did we have available at take-off?
- How many liters of oxygen did we expend in compliance with FAR 91-211 or 135-89?
- Did we use any therapeutic oxygen for our passengers?
- What flow rate and duration was anticipated?
- How much oxygen was expended in the execution of the emergency descent?
- When we reach the selected altitude with adequate specific range (SR), what will the oxygen flow rates be?

- At the flow rates calculated and the oxygen supply aboard determined, do we have enough oxygen to safely continue?

- Can we monitor the aircraft specific range, distance remaining, oxygen remaining and fuel remaining so that we can be assured of the successful completion of this trip?

If you have any doubt or are unable to quickly and expeditiously answer any of the above questions now is the time to "hit the books" and start your planning for an oxygen contingency. On a dark night over the North Atlantic or Pacific is definitely not the time to start your evaluation and training program. Do it now! Don't wait! The safe conduct and safety of your flight is YOUR responsibility.

A.D.S. has developed a three dimensional (time, distance, fuel) computer generated program to show your aircraft performance both in graphic and tabular form, with head and tail wind components calculated along with a tabulated oxygen matrix for determining oxygen aboard and oxygen duration. The availability of this information on the flight deck benefits the flight crew by providing the means to translate oxygen bottle pressure which, by itself is a meaningless number into oxygen duration. The common denominator is TIME. The charts provide the flight crew the ability to effectively balance the ETE (time) against oxygen duration (time) and thereby "trade" resources. This program provides quick, accurate answers to your oxygen situation *Before You Go!*

The Aeronautical Data Systems Oxygen Planning Program (OPP) is NOT the only way, but it is "A" way. If you develop your own program be sure to address all aspects of oxygen flight planning for your particular aircraft.

We will try to outline a suggested sequence that you can follow to determine the resources required to safely complete your flight.

- Determine the amount of fuel remaining at the Equal Time Point.

- Determine the distance to the nearest suitable airport.

- Select an altitude and cruise mode (at the appropriate aircraft gross weight) that will get you to your selected destination, with reserves, that equals or is less than the fuel remaining.

- Using the aircraft weight and TAS for the selected cruise mode, biased by the wind factor, at the selected altitude, calculate the enroute time (ETE) and establish an ETA.

- Read the oxygen pressure gauges and inventory the liters of oxygen aboard.

- Determine the oxygen flow rates (crew and passenger) at the selected altitude, multiplied by the number of passengers and crew to finally, compute your oxygen duration.

- Compare your ETE versus the oxygen duration. If the oxygen duration exceeds the ETE, you're in fine shape. Relax and monitor your flight progress!

Seems straight forward and simple enough but if you have not familiarized yourself with the above requirements and the associated charts for your airplane, you may be in for a few surprises. Charts that we have reviewed leave a lot to be desired. Some of the charts and tables give you oxygen volume in cubic feet, flow rates are always given in LPM (liters per minute)for a mask/regulator combination, this requires you to convert cubic feet of oxygen into liters so that you can determine duration. When you read bottle pressure at altitude (the aircraft and bottles have "cold soaked") is that an accurate determination of the volume? Oxygen pressure below 200 PSI is considered unusable. How many liters are unusable and deducted from the on board inventory? What cruise mode did the performance engineer use when he determined the oxygen requirements for your aircraft? Most used MSR (maximum specific range) so that the fuel requirement is optimized and you can stay in the air longer, increasing range.

The longer you stay in the air the more oxygen you require. Would you sacrifice one percent (1%) of the range to gain an eight percent (8%) increase in TAS, shortening the time in the air, thereby decreasing the oxygen requirement?

If you are having trouble addressing any of these details let us tell you that you are not alone but *let's do something about it!*

Aeronautical Data Systems (ADS) has developed a set of aircraft performance, oxygen conversion, oxygen inventory and tabulated oxygen duration charts that are "tailored" to your specific airplane and your "Internationally Configured" aircraft gross weight. With these charts you can enter the 10,000 foot chart at the estimated distance to your diversion alternate, read vertically to the line that indicates the wind component anticipated, then read left to get the fuel required (en route fuel plus reserve) in the left margin, if you have enough fuel on board, the contingency is over. If not, we must do the same on the 15,000 foot chart, then the 20,000 foot chart and finally the 25,000 foot chart until the fuel required on the chart equals or is less than the fuel remaining.

After reading the fuel required in the left margin and can meet the fuel requirement at the selected altitude, scan to the right margin and read the estimated time enroute. When your ETE and ETA are calculated, check the oxygen duration chart for that altitude and determine the oxygen duration versus passengers versus liters of oxygen on board. If you have done your planning you should have an adequate oxygen supply aboard to safely complete the flight. "Know *BEFORE* You Go"

Situations where the planning documentation will be a benefit:

- If determination of on board resources are marginal or inadequate, consider the option of fueling at the closest suitable airport to your "coast out" point.
- If the oxygen system was utilized for FAR flight crew regulatory requirements at altitude.
- Oxygen system leaked down or less than a full quantity was available at dispatch.
- Therapeutic or medical oxygen was utilized.

Any of the above situations would result in less than a full quantity of oxygen.

Oxygen duration versus the oxygen quantity and passenger load can be read directly from the oxygen duration charts. Certainly, servicing the oxygen system is the answer but may prove difficult. Refill fittings may not be adaptable to the fittings on your aircraft (British Standard or metric versus the US "AN" standards). In some countries oxygen bottles may not be refilled in the aircraft (China).

With the set of charts "tailored" for your aircraft, you will be able to conduct a accurate overview of the problems you may be exposed to and evaluate the available options, the day *BEFORE* you go!! At any rate the "tailored" charts, in harmony with a computer generated flight plan will allow the flight crew to evaluate and identify potential problems *BEFORE* take off. The Aeronautical Data Systems motto, in case you haven't noticed is "Know ***BEFORE*** You Go".

If we still haven't convinced you on the concept, we would like to bring your attention to several isolated incidents where oxygen planning could have played a role.

The first is an article in the April issue of AIN (pg. 54) where a G III at FL 450 lost a door seal, resulting in a decompression. The second was the Delta Airlines DC-9 that lost the compressor fan section of the engine that ruptured the pressure vessel. Last, but not least was a Citation II, JT 15 engine that disintegrated, puncturing the pressure vessel. Both aircraft were on take off and decompression was not a factor but the perforation of the fuselage was real. We certainly hope that you are never exposed to these problems, but they are real and require preparation and planning to achieve the performance necessary to address the situation.

SAFE FLYING!!

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