NTSB Findings (Excerpted from NTSB report NTSB/AAR-98/01**)**

1. The flightcrew was properly certified and trained for the flight, and was in compliance with Federal flight and duty time regulations.

2. The airplane was properly certificated and maintained in accordance with applicable Federal regulations, including a Federal Aviation Administration-approved airworthiness maintenance program.

3. Visual meteorological conditions prevailed, and weather was not a factor in the accident.

4. The oil observed preflight by the first officer came from the No. 1 bearing housing and, therefore, was not a precursor to the accident.

5. Some form of drill breakage or drill breakdown, combined with localized loss of coolant and chip packing, occurred during the drilling process, creating the altered microstructure and ladder cracking in the accident fan hub.

6. Fatigue cracks initiated from the ladder cracking in the tierod hole and began propagating almost immediately after the hub was put into service in 1990.

7. Although the altered microstructure in the accident hub tierod hole was detectable by blue etch anodize inspection methods, Volvo did not identify it as rejectable because the appearance of the tierod hole did not match any of the existing inspection templates showing rejectable conditions.

8. Although the additional templates will assist blue etch anodize inspectors in detecting potential defects similar to the one that existed on the accident hub, this accident suggests that there may be additional rejectable conditions that have not yet been identified.

9. Drilling damage in this accident hub extended much deeper into hole sidewall material than previously anticipated by Pratt & Whitney.

10. The crack was large enough to have been detectable during the accident hub's last fluorescent penetrant inspection at Delta.

11. Significant questions exist about the reliability of flash drying in removing water from cracks.

12. Better techniques are needed to ensure the fullest possible coverage of dry developer powder, particularly along hole walls.

13. Although it could not be conclusively determined whether this played a role in the nondetection of the crack in the accident hub, the absence of a system that formally tracks

the timing of the movement of parts through the fluorescent penetrant inspection process was a significant deficiency.

14. Fluorescent penetrant inspection indications remain vulnerable to manual handling, and fixtures used to support the part during inspection may obstruct inspector access to areas of the part.

15. One or more procedural deficiencies in the cleaning, drying, processing, and handling of the part might have reduced or prevented the effectiveness of Delta's fluorescent penetrant inspection process in revealing the crack.

16. The potential deficiencies identified in the Delta fluorescent penetrant inspection process may exist at other maintenance facilities and be, in part, the reason for the failure to detect cracks in other failed engines identified in this investigation.

17. No personal or physical factors would have prevented the FPI inspector from detecting a visible crack in the accident hub.

18. An inadvertent failure of the inspector to systematically search and complete follow-up diagnosis when necessary on all surfaces of the hub might have caused the FPI inspector to overlook the crack.

19. A low expectation of finding a crack in a -219 series fan hub might have caused the FPI inspector to overlook or minimize the significance of an indication.

20. The duration of inspections and the amount and duration of rest periods may indeed affect inspector performance, but this potential has not been adequately studied in the aviation domain.

21. Because of the potentially catastrophic consequences of a missed crack in a critical rotating part, testing methods that evaluate inspector capabilities in visual search and detection and document their sensitivity to detecting defects on representative parts are necessary.

22. Delta's nondetection of the crack was caused either by a failure of the cleaning and fluorescent penetrant inspection processing, a failure of the inspector to detect the crack, or some combination of these factors.

23. Manufacturing and in-service inspection processes currently being used do not provide sufficient redundancy to guarantee that newly manufactured critical rotating titanium engine parts will be put into service defect-free and will remain crack-free through the service life of the part. Further, all critical rotating titanium engine components are susceptible to manufacturing flaws and resulting cracking and uncontained engine failures that could potentially lead to catastrophic accidents.

24. Although during the preflight inspection the first officer found a small amount of oil on the bullet nose of the left engine and two missing rivets, these were not factors in the subsequent engine failure.

25. There is a lack of clarity in written guidance in the flight operations manual to Delta flightcrews on what constitutes maintenance “discrepancies” and “irregularities” and when to contact maintenance personnel and to log anomalies.

26. The captain shut down the engines in a timely manner when he became aware of conditions in the aft cabin.

27. Neither the aft flight attendants’ decision to evacuate nor the captain’s decision not to evacuate was improper in light of the information each of them had available at the time.

28. Every passenger-carrying airplane operating under 14 Code of Federal Regulations Part 121 should have a reliable means to ensure that all crewmembers on board the airplane are immediately made aware of a decision to initiate an evacuation.

29. Safety could be enhanced if all cockpit crews were immediately made aware of when exits are opened during an emergency.

30. Guidance provided to passengers on Delta Air Lines MD-88s regarding when emergency exits should and should not be opened is not sufficiently specific.