PRODUCTION TESTING OF DOMESTIC CLOTHES DRYERS USING LMS FORTH

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ABSTRACT

This paper describes the implementation of a semi-automated testing facility for domestic clothes dryers, with particular emphasis on the system functionality, and the approach taken for controlling asynchronous concurrent tasks.

SYSTEM OVERVIEW

The client assembles several models of mid-sized (24 inch) electric clothes dryers, on a manual production line. Volume is up to 400 units per day of mixed models and voltages.

Each unit is subjected to the safety tests required by C.S.A. and U.L. at a single test station at the entrance to the testing facility. The dryer is then moved manually to one of twelve operating test stations at which all the features of the particular model are tested under simulated normal operating conditions.

Any deviation from specifications results in the printing of a failure ticket, and rejection of the unit, which is then repaired on a back-line and retested.

There is provision for running detailed tests to collect performance data on new models, in order to develop test specifications. Failure statistics are collected and may be output in a Lotus 123 compatible data file for quality control analysis. Hard disk storage is provided to store all the data for the estimated 10 year life of the line.

The computer used was an IBM PC with 128 KB RAM and single floppy, connected to a Tecmar expansion chassis containing 10 MB fixed and 5 MB removable winchesters, Tecmar LabTender A/D board, and Tecmar BaseBoard digital I/O board. A bar code reader and two printers were attached to serial and parallel ports. Software was MSDos with LMS Forth 2.00.

SAFETY TEST STATION

The assembled units arrive at the safety test station on a gravity fed conveyor and the power cord is manually plugged in to either a 220v or 110v socket on the front of the safety tester. The start of test is signalled by reading the dryer model/serial number with the bar-code wand. As soon as a valid number is received the safety test sequence is started.

The operator in response to prompting indicator lights, carries out four ground continuity tests at specified points on the dryer and then the 1200v hi-pot, current leak, and low-voltage start tests are carried out automatically, with the operator being prompted to activate the dryer start knob as required. The low-voltage start test is not a safety requirement but is grouped for convenience with the safety tests.

Failure of any of the above tests results in the test sequence being terminated and the printing of a failure ticket. The whole test sequence takes in the order of 15 - 20 seconds from start to finish.

A dryer that completes the safety tests is assigned by the computer to an empty operating test bay. The signal lamp over the selected bay is turned on and the corresponding block in the status display on the colour monitor set to flashing cyan.

OPERATING TEST STATIONS

Each of the twelve operating test stations is equipped with 220v and 110v power receptacles controlled by solid state switches and connected to a current measuring circuit. A hood fits over the exhaust vent of the dryer, and contains a solid state temperature sensor and a flap which can be locked in the closed position by the computer in order to force the dryer to overheat for a test of the safety thermostat. A microswitch is fitted in order to detect the presence or absence of airflow when the lock has been released.

An attention button and signal lamp is provided for the operator, who moves the dryer from the safety test station to the bay indicated by the illuminated signal light, plugs in the power, sets the dryer switches, and presses the attention button to signal start of test. The correct power receptacle is energized and the operator turns the start knob of the dryer.

The test runs for 20 - 30 minutes. Temperature and current are compared at 15 second intervals to values specified for the model, corrected for ambient shop temperature.

From time to time operator intervention is called for by the specifications to change switch settings on the dryer. The test is suspended, the signal lamp turned on, and an instruction to the operator is displayed on the monitor. The operator makes the neccessary adjustments and presses the attention button, turning the dryer start knob to restart the test.

At completion the operator is prompted to make a visual inspection of the finish etc. He presses the attention button to signal the start of a two minute visual inspection period and makes his visual inspection.

If all is satisfactory the operator unhooks the dryer and moves it down the conveyor for crating. Otherwise he presses the attention button before the expiration of the two minute period to signal a failure, and an failure ticket is printed on the ticket printer.

STATUS DISPLAY

The status of all the ongoing tests is shown on the monitor, which has a coloured block for each test position. The colour indicates the status of the test. Flashing cyan indicates the next selected test bay. Cyan indicates an ongoing test. Flashing yellow indicates that operator intervention is required, and an instruction message together with the bay number is displayed on the message stack. Green indicates an implied pass during the visual inspection period and flashing red, of course, indicates a failure.

Within each status block the maximum and minimum current and temperature for the previous 15 second period is displayed. Below the status blocks is space for a stack of up to five instruction messages, with the latest message inserted at the top.

FAILURE STATISTICS

For each failure, a failure ticket specifying the failure mode is generated on a 32 column ticket printer, and attached to the unit.

The repair technician marks this ticket with up to four of approximately 100 possible repair codes. At the end of each day they are collected and the repair codes batch entered into the previously created error records. A daily report is printed on the 80 column Epson printer, with repairs listed in descending order of frequency. This is useful for detecting faulty assembly procedures or batches of components. These error records may also be output to disk as a Lotus .PRN file for production of weekly and monthly analytical reports.

SOFTWARE DESIGN CONSIDERATIONS

LMS Forth has some limited multitasking capabilities, but the lack of separate stacks and the ability easily to control transfer of execution between background tasks made its multitasker unsuitable for this system, and it was decided to implement a single round-robin executive using a DO WHILE loop. Tasks carried out in order in this loop are:

- Scanning the A/D and digital I/O channels and updating the associated arrays.

- Carrying out one operation of the Safety Test sequence. (s-main)

- Scanning all the Operating Test bays and testing those which have fallen due. (o-main)

- Sending a line of an error report to the ticket printer. (p-main)

For the safety test, logic flow is controlled by storing values in the counter #safety-test. For example, a WAIT UNTIL ....TRUE is implemented by decrementing the counter for a many loops as neccessary. A jump to failure processing is implemented by storing 99 in the counter #safety-test.

For the operating test, all data, flags and counters are contained in 12 element arrays, addressed by the loop counter.

PSEUDOCODE OF MAIN TESTING ALGORYTM

```
BEGIN main testing program       ( t-main )
    Load variables from disk     ( t-load )
    Display screen mask          ( t-disp-mask )
    DO testing UNTIL <ESC> is pressed from the keyboard  ( t-testing )
        Update ##current-time from the system clock      ( t-time )
        Scan buttons and set flags in array $buttons  ( t-scan-buttons )
        Scan flaps and set flags in array $flaps      ( t-scan-flaps )
        Scan 32 A/D channels, updating arrays $sum, $count, $max, $min
        BEGIN safety tests                    ( s-main )
            CASE of #safety-test / 10
                0 - read the model/serial number     ( s-read-barcode )
                1 - first ground test                ( s-ground1 )
                etc...
                9 - assign unit to operating bay     ( s-nextbay )
               10 - OR deal with failed unit         ( s-failsafety )
            ENDCASE
            Increment counter #safety-test by 1  ( t-incr-st )
        END                                      ( s-main )
        BEGIN operating tests                    ( o-main )
            DO FOR bay 1 to 12
                IF bay(I) is active
                AND IF test is due i.e. >= 15 sec since last test
                    Extract the model# from array element $sernum(I)
                    Read specs for the model and test cycle from disk
                    Compare specs with actual values of current, temp.
                    IF everything O.K.
                        Update screen display
                        Read action for next test cycle from disk
                        Display instruction message if required
                        Incr. array elements $testcycle(I), $testtime(I)
                    ELSE failure
                        Store fail code in array element $bayfailed(I)
                    ENDIF
                ENDIF
            ENDO
        END                                      ( o-main )
        BEGIN print error reports                ( p-main )
           IF printer ready for new line, i.e. CTS line low
               Search array $bayfailed for first non-zero value
               IF #linecount = 0
                   Write error record to disk
               ENDIF
               Send one line of error report to printer
               Increment counter #linecount by 1
           ENDIF
        END                                      ( p-main )
    ENDO                              ( t-testing )
    Save variables to disk etc.          ( t-save )
END                                   ( t-main )
```