

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE
NUMBER: 05-6BA-2118-IM -X

SUBSYSTEM NAME: EPD&C - LANDING GEAR CONTROL
REVISION: 6 **04/09/92**

PART DATA

PART NAME	PART NUMBER
VENDOR NAME	VENDOR NUMBER
LRU : ELECTRONIC, PROXIMITY SWITCH	MC452-0124-0009

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
ELECTRONIC, PROXIMITY SWITCH SENSOR PACKAGE, NO. 1 AND NO. 2

REFERENCE DESIGNATORS: 81V51A1-NO. 1
 82V51A2-NO. 2

QUANTITY OF LIKE ITEMS: 2
TWO, NO. 1 IN FWD BAY 1 AND NO. 2 IN FWD BAY 2

FUNCTION:
PROVIDES THE ELECTRONICS FOR SENSING THE DISCRETE POSITION OF MOVING PARTS/ASSEMBLIES WITHIN THE LANDING GEAR CONTROL SUBSYSTEM. PROVIDES POWER, REGULATION, AMPLIFICATION, SELF-TEST AND PROCESSING THROUGH 10 CIRCUIT CARD CHANNELS TO DESIGNATED REMOTE SENSORS.

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REVISION#: 7 07/01/99

SUBSYSTEM NAME: EPD&C - LANDING GEAR CONTROL

LRU: ELECTRONIC, PROXIMITY SWITCH

CRITICALITY OF THIS

ITEM NAME: ELECTRONIC, PROXIMITY SWITCH

FAILURE MODE: 1R2

FAILURE MODE:

LOSS OF OUTPUT, FAILS TO CONDUCT, OPEN, SHORTS TO GROUND

MISSION PHASE: DO DE-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

102	COLUMBIA
103	DISCOVERY
104	ATLANTIS
105	ENDEAVOUR

CAUSE:

PIECE PART STRUCTURAL FAILURE, MECHANICAL SHOCK, THERMAL SHOCK, VIBRATION

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

A) PASS
B) PASS
C) PASS

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

FIRST FAILURE - LOSS OF SENSOR OUTPUT FROM ONE OF TEN CHANNELS IN ONE ELECTRONIC PACKAGE

(B) INTERFACING SUBSYSTEM(S):

FIRST FAILURE - NO EFFECT

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(C) MISSION:
FIRST FAILURE - NO EFFECT

(D) CREW, VEHICLE, AND ELEMENT(S):
FIRST FAILURE - NO EFFECT

(E) FUNCTIONAL CRITICALITY EFFECTS:
THE FOLLOWING ARE THE CRITICAL CHANNELS AND FAILURE EFFECTS ASSOCIATED WITH BOTH PROXIMITY SWITCH ELECTRONIC PACKAGES (NO. 1 AND NO. 2):

PROXIMITY SWITCH ELECTRONIC PACKAGE NO. 1:

CHANNEL 1 : 1R3, PPP
REFERENCE FMEA'S : 05-6BA-2400-IM-1, 05-6BB-2096-IM-3

FIRST FAILURE - 50% OF BRAKING CAPABILITY IS ENABLED.
2ND-3RD FAILURE - ("HYD SYS BRAKE ISOL VALVE" SWITCH AND CHECK VALVE FAIL CLOSED RESULTING IN UNCOMMANDED BRAKE PRESSURE)
POSSIBLE LOSS OF CREW/VEHICLE DUE TO TIRE DAMAGE AT TOUCHDOWN.

CHANNEL 8 :
REFERENCE FMEA'S : 05-6BA-2407-IM-1, 05-6BB-2107-IM-1

CASE 1 : 1R2, PPP
1ST & 2ND FAILURES - (ANTI-SKID SWITCH FAILS FOLLOWED BY THIS CHANNEL FAILS OFF AFTER APPROACH/LANDING INTERFACE)
FLIGHT CONTROL WILL BE AFFECTED SINCE WEIGH-ON-WHEELS IS ERRONEOUSLY CONFIRMED. TESTING AT AMES LABORATORY HAS FOUND THAT THIS SCENARIO WILL RESULT IN DEGRADATION OF AERSURFACE CONTROL WHICH MAY RESULT IN LOSS OF CREW/VEHICLE.

CASE 2 : 1R3, PPP
FIRST FAILURE - 100% OF BRAKING CAPABILITY IS ENABLED.
2ND-3RD FAILURE - ("HYD SYS BRAKE ISOL VALVE" SWITCH AND CHECK VALVE FAIL CLOSED RESULTING IN UNCOMMANDED BRAKE PRESSURE)
POSSIBLE LOSS OF CREW/VEHICLE DUE TO TIRE DAMAGE AT TOUCHDOWN.

CHANNEL 3, 6 : 1R3, PPP
REFERENCE FMEA'S : 05-6BA-2575-IM-1, 05-6BA-2410-IM-1

FIRST FAILURE - UNABLE TO UNLOCK THE UPLOCK HOOKS VIA ASSOCIATED PIC.

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- SECOND FAILURE - (REDUNDANT PIC) UNABLE TO UNLOCK THE UPLOCK HOOKS VIA
PIC THIRD FAILURE
THIRD FAILURE - (LOSS OF HYDRAULIC SYSTEM NO. 1) POSSIBLE LOSS OF
CREW/VEHICLE DUE TO INABILITY TO EXTEND LANDING
GEARS.

NOTE: CHANNEL 2 IS USED FOR INDICATION ONLY; CHANNELS 5, 7, 9, AND 10 ARE
NOT BEING USED.

LOSS OF OUTPUT OF CHANNEL 4 WOULD RESULT IN FIRING OF THE
UNLATCH PYRO ONE SECOND AFTER THE "DOWN" COMMAND IS ISSUED
REGARDLESS OF THE STATE OF THE UPLOCK HOOKS (LOCK OR UNLOCK).
THIS IS CRITICALITY 3/3 FAILURE.

PROXIMITY SWITCH ELECTRONIC PACKAGE NO. 2:

CHANNEL 1 : 1R3, PPP
REFERENCE FMEA'S : 05-6BA-2400-IM-1, 05-6BB-2096-IM-3

FIRST FAILURE - 50% OF BRAKING CAPABILITY IS ENABLE.
2ND-3RD FAILURE - ("HYD SYS BRAKE ISOL VALVE" SWITCH AND CHECK VALVE FAIL
CLOSED RESULTING IN UNCOMMANDED BRAKE PRESSURE)
POSSIBLE LOSS OF CREW/VEHICLE DUE TO TIRE DAMAGE AT
TOUCHDOWN.

CHANNEL 3 : 1R2, PPP
REFERENCE FMEA'S : 05-6BA-2407-IM-1, 05-6BB-2107-IM-1

CASE 1 : 1R2, PPP
1ST & 2ND
FAILURES - (ANTI-SKID SWITCH FAILS FOLLOWED BY THIS CHANNEL
FAILS OFF AFTER APPROACH/LANDING INTERFACE)
FLIGHT CONTROL WILL BE AFFECTED SINCE WEIGH-ON-WHEELS
IS ERRONEOUSLY CONFIRMED. TESTING AT AMES LABORATORY
HAS FOUND THAT THIS SCENARIO WILL RESULT IN DEGRADATION
OF AERSURFACE CONTROL WHICH MAY RESULT IN LOSS OF
CREW/VEHICLE.

CASE 2 : 1R3, PPP
FIRST FAILURE - 100% OF BRAKING CAPABILITY IS ENABLED.
2ND-3RD FAILURE - ("HYD SYS BRAKE ISOL VALVE" SWITCH AND CHECK VALVE FAIL
CLOSED RESULTING IN UNCOMMANDED BRAKE PRESSURE)
POSSIBLE LOSS OF CREW/VEHICLE DUE TO TIRE DAMAGE AT
TOUCHDOWN.

CHANNEL 2, 6 : 1R3, PPP
REFERENCE FMEA'S : 05-6BA-2575-IM-1, 05-6BA-2410-IM-1

FIRST FAILURE - UNABLE TO UNLOCK THE UPLOCK HOOKS VIA ASSOCIATED PIC.
SECOND FAILURE - (REDUNDANT PIC) UNABLE TO UNLOCK THE UPLOCK HOOKS VIA
PIC.

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THIRD FAILURE - (LOSS OF HYDRAULIC SYSTEM NO. 1) POSSIBLE LOSS OF CREW/VEHICLE DUE TO INABILITY TO EXTEND LANDING GEARS.

NOTE: CHANNELS 7 AND 8 ARE USED FOR INDICATION ONLY; CHANNELS 5, 9, AND 10 ARE NOT BEING USED.

LOSS OF OUTPUT OF CHANNEL 4 WOULD RESULT IN FIRING OF THE UNLATCH PYRO ONE SECOND AFTER THE "DOWN" COMMAND IS ISSUED REGARDLESS OF THE STATE OF THE UPLOCK HOOKS (LOCK OR UNLOCK). THIS IS CRITICALITY 3/3 FAILURE.

-DISPOSITION RATIONALE-

(A) DESIGN:

PHYSICAL DESCRIPTION

THE PROXIMITY SWITCH SYSTEM (MC452-0124) CONSISTS OF TWO PIECES, ELECTRONIC PACKAGE AND SENSORS. THE ELECTRONIC PACKAGE CONTAINS TEN CHANNELS COMPOSED OF INTEGRATED PRINTED CIRCUIT CARDS (SWITCH CARDS) MOUNTED TOGETHER WITHIN A VENTED, ALL WELDED METAL CLOSURE ENVELOPE. EACH CHANNEL HAS AN ASSOCIATED REMOTE LOCATED SENSOR. BOTH THE ELECTRONIC PACKAGE AND SENSOR(S) ARE LINE REPLACEABLE UNITS (LRU).

ALL ELECTRICAL AND ELECTRONIC COMPONENTS ARE SELECTED FROM OR IN ACCORDANCE WITH THE ORBITER PREFERRED PARTS LIST (OPPL) REQUIREMENTS.

FUNCTIONAL DESCRIPTION

THE PROXIMITY SWITCH SYSTEM PERFORMS THE FUNCTION OF SENSING THE DISCRETE POSITION OF MOVING PARTS. WHEN THE SENSOR DETECTS THE PRESENCE OF A FERROUS METAL TARGET THE ASSOCIATED ELECTRONIC CHANNEL'S OUTPUT CHANGES LOGIC STATE AND SIGNALS THE STATUS OF THE MOVING OBJECT BEING MONITORED. BUILT-IN-TEST CAPABILITY WITHIN THE SYSTEM DETECT AND REPORT FAILURES WHICH WOULD AFFECT THE SYSTEM'S OPERATION.

DESIGN EVOLUTION

DURING THE VARIOUS TEST PHASES, THE ELECTRONIC PACKAGE (-0002) EXPERIENCED SEVERAL FAILURES ANALYZED AS INSULATION BREAKDOWN PROBLEMS. THE SUPPLIER'S CORRECTIVE ACTION WAS IMPLEMENTED AND INCORPORATED INTO THE MC452-0124-0009 CONFIGURATION. THE CHANGE WAS AUTHORIZED BY MCR 5916 WITH EFFECTIVITY FOR ALL FLIGHT VEHICLES. THE MODIFICATION INCLUDED INCREASED AIR GAPS, THICKER INSULATION AND ATP CHANGES TO ASSURE APPROPRIATE ISOLATION. (REFERENCE CAR AB3758) NO DESIGN CHANGES WERE MADE TO THE SENSORS. THEY WERE ORIGINALLY ASSIGNED NUMBERS ACCORDING TO THE CLASSIFICATION WHICH REFLECTS THE DIRECTION THEIR LEAD WIRES EXIT.

(B) TEST:

CERTIFICATION/APPROVAL

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THE PROXIMITY SWITCH SYSTEM WAS CERTIFIED BY ACTUAL TEST AND BY SIMILARITY. THE CERTIFICATION IS CR 21-452-0124-0002D AS REFERENCED BY CAR 01B-21-452-0124-0000. THE APPROVED CERTIFICATION IS EFFECTIVE FOR ALL FLIGHT VEHICLES.

QUALIFICATION TESTS

ACCEPTANCE TEST (REF)
POWER TEST

EMC

SALT FOG (SENSOR ONLY)
CABIN ATMOSPHERE (ELECTRONIC PACKAGE ONLY)

THERMAL CYCLE

VIBRATION - QAVT - 0.067G2/HZ
FLIGHT - 0.09G2/HZ

THERMAL VACUUM

LIFE

LIGHTING

SHOCK (LANDING) (SENSOR ONLY)

SHOCK (BENCH HANDLING)
(ELECTRONIC PACKAGE ONLY)

SHOCK (BASIC DESIGN)

SHOCK (CRASH SAFETY)
(ELECTRONIC PACKAGE ONLY)

ACCEPTANCE TEST

ACCEPTANCE TEST AND INSPECTION ARE PERFORMED ON ALL ELECTRONIC PACKAGES AND SENSORS TO BE UTILIZED ON ORBITERS AND INCLUDE THE FOLLOWING:

EXAMINATION OF PRODUCT
PERFORMANCE
DIELECTRIC STRENGTH TEST
ACCEPTANCE VIBRATION TEST
ACCEPTANCE THERMAL TEST
INSULATION RESISTANCE TEST

GROUND TURNAROUND TEST

ANY TURNAROUND CHECKOUT TESTING IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

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(C) INSPECTION:

RECEIVING INSPECTION:

RECEIVING INSPECTION VERIFIES PURCHASED MATERIALS TO THE EXTENT NECESSARY TO ASSURE CONFORMANCE TO THE APPLICABLE TECHNICAL REQUIREMENTS OF THE PURCHASE ORDER AND DRAWING, PER DOCUMENTED POLICY. ENGINEERING SPECIFIES CRITICAL AND MAJOR PARAMETERS OF PURCHASED PARTS AND MATERIALS TO BE VERIFIED BY RECEIVING INSPECTION, PER DOCUMENTED REQUIREMENTS. ALL CERTIFICATION RECORDS AND TEST REPORTS ARE MAINTAINED WITH THE ORIGINAL RECEIVING REPORT AND PACKING SLIP. COMPLETED RECEIVING REPORTS ARE MAINTAINED IN THE CLOSED PURCHASE ORDER FILE PER DOCUMENTED PROCEDURES.

CONTAMINATION CONTROL:

QUALITY ASSURANCE (QA) MONITORS AND AUDITS SHOP AREAS TO ENSURE THAT THE RESPONSIBLE PARTIES ARE IN COMPLIANCE WITH ALL SPECIFIED CONTAMINATION CONTROLS, PER DOCUMENTED INSTRUCTIONS.

ASSEMBLY/INSTALLATION:

IN-PROCESS INSPECTION POINTS ARE ESTABLISHED BY QA TO ENSURE ACCEPTABILITY OF ITEMS PRIOR TO SUBSEQUENT PROCESSING OR STOCKING, WHEN SUCH PROCESSING WOULD MAKE VERIFICATION OF ACCEPTABILITY OF PREVIOUS OPERATIONS IMPOSSIBLE, PER DOCUMENTED INSTRUCTIONS. A CRIMP LOG IS MAINTAINED, AND CRIMP TOOL CALIBRATION VERIFICATION COMPLIES WITH MSC- SPEC-Q-1A.

ALL BRAZED JOINTS AND CRIMPS ARE VISUALLY INSPECTED.

CRITICAL PROCESSES:

PROCESSING OPERATIONS ARE MONITORED FOR COMPLIANCE WITH QUALITY REQUIREMENTS, AND QA PERFORMS AUDITS TO VERIFY THAT PROCESSING REQUIREMENTS ARE MET. CRITICAL PROCESSES ARE BRAZING, CRIMPING, SPOT WELDING, SOLDERING, SWAGING, COMPONENT BONDING, CONFORMAL COATING, AND HARNESS/CABLE FABRICATION.

TESTING

QA REGULARLY CONDUCTS SURVEILLANCE OF PRODUCT TESTING IN ACCORDANCE WITH DOCUMENTED INSTRUCTIONS. A PULL TEST IS PERFORMED FOR EVERY ONE HUNDRED SPOT WELDS.

HANDLING/PACKAGING:

PARTS PACKAGED AND PROTECTED ARE VERIFIED BY INSPECTION TO APPLICABLE REQUIREMENTS. SPECIAL HANDLING PER DOCUMENTED INSTRUCTIONS IS VERIFIED, TO PRECLUDE DAMAGE, SHOCK, AND CONTAMINATION DURING COMPONENT HANDLING/TRANSPORTING/PACKAGING BETWEEN WORK STATIONS. CONTROLS ARE IMPLEMENTED TO PREVENT ELECTROSTATIC DISCHARGE, AND THE MAINTENANCE OF CONTROLS IS AUDITED BY QA.

(D) FAILURE HISTORY:

CURRENT DATA ON TEST FAILURES, FLIGHT FAILURES, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE

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FOUND IN THE PRACA DATA BASE. THE FAILURE HISTORY DATA PROVIDED BELOW IS NO LONGER BEING KEPT UP-TO-DATE.

PROXIMITY SWITCH ELECTRONIC PACKAGE FAILURES

MC452-0124-0002 - CONFIGURATION

CAR AB3758 PRIME, A6003, AB2310, AB3258
DURING OVERPRESSURE TEST THE PROXIMITY SWITCH ELECTRONIC PACKAGE (MC452-0124-0002) DISCLOSED FIVE INOPERATIVE CHANNELS.

ANALYSIS FOUND A VOLTAGE REGULATOR (A51) SHORTED TO ITS MOUNTING BRACKET. A BURNT PATH INDICATED A MOMENTARY SHORT, REGULATOR TO CHASSIS, BURNING OPEN DURING PREVIOUS ISOLATION RESISTANCE TEST, WHERE THE ANOMALIES WERE RECORDED AND THE IR TEST WAS REPEATED SUCCESSFULLY.

SUPPLIER'S CORRECTIVE ACTION CONSISTED OF REVISIONS TO DRAWING ADDING COUNTER SINK HOLE TO MOUNTING/HEATSINK BRACKET, ADDING LARGER INSULATORS, AND CHANGING THE ATP TO ASSURE APPROPRIATE ISOLATION TESTS. THE CHANGES ARE TO LIMIT ELECTRICAL ARCING AND INSULATION BREAKDOWN IN THE PACKAGES. THIS ACTION WAS PREVIOUSLY OUTLINED IN CAR - A6003, BUT IMPROPERLY IMPLEMENTED (REF-EDCP 441-392-640-1). SUBSEQUENT FAILURE REPORTED ON CARS AB2310 (OV102 CHECKOUT) AND AB3258 (SUP-ATP) EXPERIENCED INSULATION BREAKDOWNS AND ARE SUBJECTED TO THIS CORRECTIVE ACTION. THE MODIFICATIONS INITIATED BY MCR 5916 ARE INCORPORATED INTO THE MC452-0124-0009 CONFIGURATION EFFECTIVE FOR ALL FLIGHT VEHICLES.

MC452-0124-0009 CONFIGURATION, OV102 AND SUBSEQUENT ORBITER

FAILURE MODE: LOSS OF OUTPUT, FAILS TO CONDUCT, OPEN, SHORTS TO GROUND

CAR AD5931

WHILE PERFORMING INCOMING FUNCTIONAL TEST, THE BOX WAS RETURNED FROM KSC FOR AN UNRELATED ANOMALY. THE SPARE CHANNEL (9) WAS FOUND NOT RESPONDING TO EXTERNAL STIMULI. THE FAILURE WAS CAUSED BY A SHORTED TRANSISTOR (Q4). THIS WAS ATTRIBUTED TO SILVER EPOXY WHICH EXTENDED FROM THE TRANSISTOR COLLECTOR TO EMITTER. THE PROBLEM IS CONSIDERED TO BE AN ISOLATED INCIDENT.

CAR AD7078

DURING NSLD TESTING, THE CHANNEL 1 HY-23 HYBRID REMAINED IN THE "TARGET FAR" POSITION WHEN IT SHOULD TOGGLE TO "TARGET NEAR". THE ANOMALY WAS CAUSED BY CAPACITOR C102 ON THE INPUT OF THE HYBRID. A SOLDER BLOB WAS FOUND ON THE CAPACITOR BRIDGING THE POSITIVE TERMINAL TO CASE. THIS ANOMALY IS CONSIDERED TO BE AN ISOLATED INCIDENT.

CAR KB0799

DURING OV-102 TESTING, THE BITE CIRCUITRY WAS ENABLED FOR THE PROXIMITY SWITCH; ALL CHANNELS OPERATED CORRECTLY EXCEPT FOR CHANNEL 8. IT INDICATED "OFF" WHEN IT SHOULD BE "ON". THE HYBRID WAS REMOVED AS A SUSPECT CAUSE, BUT NO CAUSE WAS FOUND. THIS CAR WAS CLOSED AS AN UNEXPLAINED ANOMALY.

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CAR AD1451

DURING VERIFICATION TESTING AT THE SHUTTLE AVIONICS INTEGRATION LAB (SAIL), THE OUTPUT OF CHANNEL 2 ON THE PROXIMITY SWITCH ELECTRONIC PACKAGE INTERMITTENTLY DROPPED TO 2.5-3.0 VDC FROM 4.5-5.0 VDC LEVEL. THE FAILED HYBRID (LDC 7519) WAS REMOVED. THE ANOMALY WAS ATTRIBUTED TO THE NICHROME RESISTOR BEING ETCHED AWAY BY CORROSIVE ELEMENTS. THE PROBLEM WAS CLOSED AS ISOLATED INSTANCE.

CAR 28RF04

DURING S0007 MONITORING, IT WAS NOTED THAT THE OUTPUT OF CHANNEL 1 IN ONE OF THE PROXIMITY SWITCH ELECTRONIC PACKAGE WAS SHORING "OFF" WHEN IT SHOULD BE "ON". THE FAILED HYBRID (LDC 7519) WAS REMOVED. ANALYSIS INDICATED THAT HYBRID FAILED LEAK TEST AND EXHIBITED SOME THINNING OF THE RESISTOR ELEMENT (R6). THE THINNING OF THE RESISTOR WAS CAUSED BY A COMBINATION OF MOISTURE AND CORROSIVE ELEMENTS. THIS FAILURE IS SIMILAR TO THE PROBLEM THAT OCCURRED AT SAIL (CAR1451). THE PROBLEM IS STILL IN WORK.

PROXIMITY SWITCH SENSOR FAILURES

NO DESIGN OR GENERIC FAILURES ARE NOTED ON PRODUCTION DELIVERED SENSORS. IN GENERAL, MINOR ANOMALIES, NOT INDICATIVE OF A SENSOR OR COMPONENT FAILURE, BUT OF ALIGNMENT OR A POSITION PROBLEMS EXPERIENCED DURING POTTING AND CURING PROCESS WERE EXPERIENCED. THE SENSOR WAS UPGRADED DURING SUPPLIER IN-HOUSE MANUFACTURING PROCESSES BEFORE PREACCEPTANCE AND FINAL PRODUCTION. ALL PRODUCTION SENSORS DELIVERED HAVE SUCCESSFULLY COMPLETED ACCEPTANCE TEST AND ARE SATISFACTORY FOR THEIR INTENDED USER. THEY ARE IDENTIFIED AS MC462-0124-0003, -0004, -0005, -0006 AND -0008.

(E) OPERATIONAL USE:

CORRECTIVE ACTION IN THE EVENT OF A FAILURE IS NONE

- APPROVALS -

EDITORIALLY APPROVED
TECHNICAL APPROVAL

: BNA
: VIA APPROVAL FORM

: J. Kimura 7/6/99
: 96-CIL-011_05-6BA(2)