

Swedish National Testing Institute

Physics and Electrotechnics

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Type testing of radar speed meter RC-110

(3 Appendixes)

SUMMARY

The RC 110 radar speed meter has been type tested by the Swedish National Testing Institute. The scope of the type testing is shown in SPKB 1990:07.

With the exception of tests on electrostatic discharge and enclosure class testing, the measurement equipment has worked well on all tests after modification. The above tests, which are not approved, do not affect legal security. On the other hand, poorer reliability could be anticipated. The measurement equipment complies with the requirements in SPKB 1990:07 in terms of legal security.

1 INTRODUCTION

The purpose of type testing RC-110 radar has been to examine whether the instrument complies with the The National Swedish Police Board's and the National Swedish Testing Institute's requirements for legal security and reliability. Tests have been divided into three sections: visual inspection, laboratory testing and field trials.

2 THE CLIENT

The Technical Bureau of the National Swedish Police Board.

TEST OBJECTS

A complete radar speed meter comprises:

RC-110 control unit	Trafikanalys AB	Serial number 3601
RC-110 radar unit	Trafikanalys AB	Serial number 3601
RC-110 zero key	Trafikanalys AB	No serial number

RC-110 display
Charger 8421

Trafikanalys AB
Mascot Electronic AS

No serial number
No serial number

The test objects were provided by the manufacturer, Trafikanalys AB, Gävle, Sweden.

Technical documentation in the form of technical descriptions and the required drawings were submitted to the National Swedish Testing Institute.

4 FUNCTIONAL CONTROL

During laboratory tests, it was considered that the radar speed meter operated correctly and it was possible to carry out calibration of it from the control unit. The calibration signal is generated in the microwave section.

5 TYPE TESTING

5.1 Visual inspection

5.2.1 Procedure

This inspection was carried out to examine whether the measurement equipment complies with the National Swedish Police Board's specifications. The examination confirmed that the RC-110 radar complies with the required specifications.

There are no objections concerning the measurement equipment's surface treatment or finish. The construction of the radar unit does not comply with the requirements in accordance with SS IEC 529 IP 54 with respect to dust-tightness or water-tightness (Appendix B.2.6).

No objections were raised against the measurement equipment's circuit cards, soldering or cable routing.

5.2.2 Documentation review

A documentation review was carried out to verify that the measurement equipment is clearly described. The documentation agrees well with the equipment submitted.

That part of the software and the components that affect measurement accuracy have been checked for compliance with legal security. No objections were raised.

5.3 Laboratory tests

5.3.1 Inspection of discrimination functions

5.3.1.1 Direction discrimination

The function which blocks registration of vehicles travelling in the wrong direction was checked. No objections were raised.

5.3.1.2 Speed discrimination

The function which blocks registration of vehicles travelling at a speed below a certain value was checked. No objections were raised.

5.3.2 Functional tests at different battery voltages

The meter is designed so that measurement is discontinued if the battery voltage goes below a certain level. The operator is given an error message on the terminal in the control unit at the same time. The battery monitor operated satisfactorily. The lower limit for the battery voltage on the radar unit was 11.5 V.

The function of the meter was tested at +20% and -10% of the nominal battery voltage. No objections against the function of the meter were raised during the test. The error message "low batt" was displayed at -10% of the nominal battery voltage.

5.3.3 Physical testing

The meter was subjected to the following physical tests. Unless stated otherwise, all components in the test object were subjected to the tests. Storage testing was carried out on the equipment in its respective packaging.

5.3.3.1 Testing in heat IEC 68-2-2 Bd

Requirements: +70°C for 96 hours (storage)
+ 55°C for 16 hours (working)

5.3.3.2 Testing in cold IEC 68-2-1 Ad

Requirements:

- 40°C for 96 hours (storage)
- 30°C for 16 hours (working)

5.3.3.3 Moisture testing IEC 68-2-30 Db

Requirements: +25°C/+55°C, 2 cycles (working)

5.3.3.4 Impact testing IEC 68-2-29 Eb

Requirements: 3 x 1000 impacts, half sinus, 25 g/6 ms (storage)

5.3.3.5 Vibration testing IEC 68-2-36 Fdb

Requirements: 10 - 500 Hz, ASD = 0.005 g²/Hz
3 x 30 minutes (working)

5.3.3.6 Enclosure class testing IEC 529

Requirements: IP 54

5.3.3.7 Electromagnetic compatibility

5.3.3.7.1 Emission

The equipment shall comply with the requirements in MIL-STD Part 4 RE 02.

5.3.3.7.2 Immunity

Radiated interference, SS IEC 801-3

10 V/m, 27-1000 MHz, modulation 50% AM square wave.

Cable-bound interference SS 436 1503

This has not been carried out since the radar speed meter was not connected to 220V while in use.

5.3.3.8 Electrostatic discharge IEC 801-2

Requirement: U = 8 kV (working)

The test was carried out only on the control unit since it was deemed improbable that the radar unit would be subjected to electrostatic discharge (Appendix B.2.8).

5.3.3.9 Results of physical tests

All the tests, with the exception of the enclosure test (Appendix B.2.6) and electrostatic discharge (Appendix B.2.6) were carried out without any comments being noted. In certain cases, these tests were carried out after modifications were carried out by the manufacture. None of the modifications were such that earlier tests were repeated. The faults that occurred affected only the reliability and not the legal security. Refer to Appendix B for more detailed results of physical tests.

6 FIELD TESTS

6.1 Procedure

During field tests, 600 measurements were carried out in the speed range of 70-90 km/h, 100 measurements in the speed range 30-50 km/h and 100 measurements in the speed range 130-150 km/h. The tests were carried on highway R40 at Kronäng, approximately 10 kilometres east of Borås. The reference car's speed was measured by using a fifth wheel fitted with a pulse sender and a frequency counter.

6.2 Sources of errors

The inaccuracy of the measurement wheel in the range 70-90 km/h contributed +/- 0.36 km/h and +/- 0.18 km/h.

A more comprehensive analysis of the sources of errors in the results is given in Appendix C.

6.3 Results

The results are shown in Appendix A where the difference between the meter's and the reference meter's speed is shown in the histograms.

In the range of 70-90 km/h the smallest difference was 0.8 km/h lower than the reference speed and the greatest difference was 4.2 km/h lower than the reference speed. The average value was 2.48 km/h lower than the reference speed.

Bearing in mind the measurement inaccuracy, the meter can show a maximum of 0.375 km/h less than the true speed and a minimum of 4.595 km/h less than the true speed. The confidence interval in the above calculations is 99.8%.

The same tendency occurs in the other speed ranges. At no time during the tests did the RC-110 Radar register a speed that was too high. The statistical processing of the results also provide sufficient reliability.

Yours sincerely,

SWEDISH NATIONAL TESTING INSTITUTE
Physics and Electrotechnics

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Appendixes

A 1-5
B 1-5
C 1-5

Appendix A 1

Field tests on an RC-110 radar speed meter

A.1 INTRODUCTION

During type testing of equipment for speed monitoring, the equipment shall be tested in a normal traffic environment. In this context, a normal traffic environment is the environment in which the meter will be used.

The difference between the reference equipment's speed and the meter's speed shall be measured. A large number of measurements is carried out to provide a statistical population.

A.2 TEST OBJECTS

The RC-110 Radar comprises a radar unit and a control unit.

A.3 FIELD TESTS

A.3.1 Procedure

During field tests, 600 measurements were carried out in the speed range of 70-90 km/h, 100 measurements in the speed range 30-50 km/h and 100 measurements in the speed range 130-150 km/h. The tests were carried on highway R40 at Kronäng, approximately 10 kilometres east of Borås. The reference car's speed was measured by using a fifth wheel fitted with a pulse sender and a frequency counter.

Appendix A 2

A.3.2 Results of the field trials

Number of cars

km/h

Figure A.1 Histogram showing the difference between the meter's and the reference equipment's speed. The tests were carried out at speeds between 70-90 km/h. 600 measurements were carried out.

Mean:	Std. Dev:	Std. Error:	Variance:
-2.4847571	0.5679223	0.0232435	0.3225357
Coeff. Var.:	Count:	Minimum:	Maximum:
-22.8562494	597	-4.2	-0.8
Range:	Sum:	Sum squared:	Missing:
3.4	-1483.4	3878.12	3

Appendix A 3

Number of cars

km/h

Figure A.2 Histogram showing the difference between the meter's and the reference equipment's speed. The tests were carried out at speeds between 30-50 km/h. 100 measurements were carried out.

Mean:	Std. Dev:	Std. Error:	Variance:
-2.0554455	0.5788739	0.0576001	0.335095
Coeff. Var.:	Count:	Minimum:	Maximum:
-28.1629426	101	-3.4	-0.8
Range:	Sum:	Sum squared:	Missing:
2.6	-207.6	460.22	0

Appendix A 4

Number of cars

km/h

Figure A.3 Histogram showing the difference between the meter's and the reference equipment's speed. The tests were carried out at speeds between 130-150 km/h. 100 measurements were carried out.

Mean:	Std. Dev:	Std. Error:	Variance:
-2.428	0.4664675	0.0466467	0.2175919
Coeff. Var.:	Count:	Minimum:	Maximum:
-19.2120054	100	-3.8	-1.5
Range:	Sum:	Sum squared:	Missing:
2.3	-242.8	611.06	0

Appendix A 5

Number of cars

km/h

Figure A.4 Histogram showing the difference between the meter's and the reference equipment's speed. The tests were carried out at speeds between 70-90 km/h and 30-50 km/h. 600 + 100 measurements were carried out.

Mean:	Std. Dev:	Std. Error:	Variance:
-2.4226361	0.5888275	0.0222875	0.3467179
Coeff. Var.:	Count:	Minimum:	Maximum:
-24.3052405	698	-4.2	-0.8
Range:	Sum:	Sum squared:	Missing:
3.4	-1691	4338.34	2

Physical testing of the RC-110 radar

B.1 INTRODUCTION

During type testing of the RC-110 radar, the equipment was subjected to physical tests. The purpose of the tests is to examine whether the equipment can operate in the environment in which it will be used.

B.2 PHYSICAL TESTING

The radar was calibrated to verify that the test object operated correctly.

B.2.1 Testing in heat

IEC 68-2-2 Bd

B.2.1.1 Storage test

Requirements: +70°C for 96 hours

The equipment was not operating during the test.

B.2.1.1.1 Result

A functional test was carried out, in accordance with B.2 above, before, during and after the test. There were no comments resulting from the functional test.

B.2.1.2 Testing while in use

Requirements: +55°C, 16 h.

The equipment was operating during the test.

B.2.1.2.1 Result

A functional test was carried out, in accordance with B.2 above, before, during and after the test. There were no comments resulting from the functional test.

Appendix B 2

B.2.2 Testing in cold

IEC 68-2-1 Ad

B.2.2.1 Storage test

Requirements: -40°C for 96 hours

The equipment was not operating during the test.

B.2.2.1.1 Result

A functional test was carried out, in accordance with B.2 above, before, during and after the test. There were no comments resulting from the functional test.

B.2.2.2 Testing while in use

Requirements: -30°C, 16 h.

The equipment was operating during the test.

B.2.2.2.1 Result

A functional test was carried out, in accordance with B.2 above, before, during and after the test. There were no comments resulting from the functional test.

B.2.3 Moisture testing

IEC 68-2-30 Db

Requirements: +25°C/+55°C, 2 cycles (working)

Only the radar unit was tested. The equipment was operating during the test.

B.2.3.1

A functional test was carried out, in accordance with B.2 above, before, during and after the test. There were no comments resulting from the functional test.

B.2.4 Impact testing

IEC 68-2-29 Eb

Requirements: 3 x 1000 impacts, half sinus, 25 g/6 ms (storage)

The equipment was kept in its packaging during the test.

B.2.4.1 Result

A functional test was carried out, in accordance with B.2 above, before, during and after the test. There were no comments resulting from the functional test.

B.2.5 Vibration testing

IEC 68-2-36 Fdb

Requirements: 10 - 500 Hz, ASD = 0.005 g²/Hz
3 x 30 minutes (working)

The equipment was in operation during the test.

B.2.5.1 Result

A functional test was carried out, in accordance with B.2 above, before, during and after the test. There were no comments resulting from the functional test.

B.2.6 Enclosure class testing

IEC 529

Requirements: IP 54

The radar unit did not comply with the requirements in accordance with IP 54. The assessment was based on the following:

- 1) The electronics for the battery monitoring and voltage control lay unprotected down amongst the internal batteries. Water and dust would in all probability collect on live parts.
- 2) The cover for the electronics card at the top of the radar unit did not have any serviceable sealing and, as a consequence, water and dust could also penetrate this area.

It was considered necessary to carry out spray and dust tests. Visual inspection was sufficient.

B.2.6.1 Result

The radar unit did not comply with the requirements in accordance with IP 54.

B.2.7 Electromagnetic compatibility

B.2.7.1 Emission

MIL-STD Part 4 RE 02.

The equipment was operating during the test.

B.2.7.1.1 Result

After modification of the filter belonging to the cable between the radar unit and the control unit, the test was carried out without and comments.

A functional test was carried out, in accordance with B.2 above, before, during and after the test. There were no comments resulting from the functional test.

B.2.7.2 Immunity

SS IEC 801-3

The equipment was in operation during the test.

Requirements: 10 V/m, 27-1000 MHz, modulation 50% AM square wave.

B.2.7.2.1 Result

A functional test was carried out, in accordance with B.2 above, before, during and after the test. There were no comments resulting from the functional test.

B.2.8 Electrostatic discharge

IEC 801-2

Requirement: $U = 8 \text{ kV}$ (working)

The test was carried out only on the control unit. It was deemed improbable that the radar unit would be subjected to electrostatic discharge via the car's chassis or via the ground while getting out of the car.

B.2.8.1 Result

If discharges were carried out near the printer unit, a fuse on the control unit blew. The unit worked again after replacing the fuse.

The fault is not a legal security problem but a reliability problem.

Appendix C 1

Sources of errors in field trials on RC-110 radar

C.1 INTRODUCTION

The reference system measures the frequency of the signal from the pulse sender in the measurement wheel.

C.2 MEASUREMENT WHEEL

C.2.1 Frequency counter

During frequency counting, a frequency counter can make an error of +/- 1 pulse depending on when the counter starts and stops. The magnitude of the error is:

$$\frac{\partial V_{ref}}{\partial f} = \frac{3.6 \cdot 10^3}{k} = 0.036$$

where k is the calibration number over a distance of 1000.98 metres. The resolution of the frequency counter was such that the slightest change in the frequency resulting in a change in the displayed speed of 0.36 km/h.

C.2.2 Wheel bounce

A series of calibrations were carried out at 80 km/h.

$\mu = 100177.8$ pulses/1000.98 metres.

$\sigma_{n-1} = 75.178$

$\mu - 3.076 = 99947.00354$

$\mu + 3.076 = 100408.5965$

$\frac{3.076}{\mu} = 0.230\%$

+/- 0.230% can lie outside the confidence interval. At 80 km/h, this confidence interval corresponds to +/- 0.184 km/h.

C.3 TOTAL ERROR ANALYSIS

$$v_{\text{ref}} - v_{\text{true}} = \pm 0.36 \pm 0.184 \text{ [km/h]}$$

$$v_{\text{reg}} - v_r = \mu - 3.07\sigma \text{ (registered, see Figure A.1)}$$

$$= 2,485 \pm 1.74$$

$$v_{\text{ref}} - v_{\text{true}} = \pm 0.36 \pm 0.184$$

$$v_{\text{reg}} - v_{\text{true}} = -2.485 \pm 0.36 \pm \sqrt{(1.74^2 + 0.184^2)}$$

$$= 2,485 \pm 2.11$$

Bearing in mind the measurement inaccuracy in the tests and the calculations shown above, the RC-110 radar speed meter can display a speed which is between 0.375 and 4.595 km/h too low. The confidence interval in the above calculations is 99.8%.