Bird Strike Testing of the Viggen Aircraft at the Holloman Test Track, New Mexico, USA

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ABSTRACT

During the Autumn of 1980 seven bird strike tests were made at the test track, five of them in combination with escape system testing and two as separate tests.

The aim of the tests was to verify the bird proof of windshield canopy and structure. For bird weights around 2 lbs the windshield strength seems to agree with the existing curve while a smaller bird punched a hole at a much lower energy level.

Background, test procedures and condlusions are presented together with a few photos showing the damage to the different test objects.

BACKGROUND

In Sweden where more than 50 % of the border is out at sea there is a lot of flying made in bird areas. Over the years there has been quite a few bird strikes, even fatal ones, which leads to new interest in bird strike testing.

Originally the Viggen windshield was tested in a prototype configuration using a gun and from those tests we got the "energy curve" which was to be checked.

The cost of a pure bird strike program at the test track would have been quite prohibitive but as we already had an escape system test planned, we could combine the two programs and thus get the costs down to a reasonable level.

To make it possible to include the canopy and the structure in front of the windshield in the tests, two extra runs were made.

TEST OBJECTS AND TEST EQUIPMENT

The windshield is made of stretched acrylic 23 mm thick and has a single curvature with a radius of 400 mm. In the test-condition with the "aircraft" centerline parallel to the rails, the impact angle was 28° and the impact point 2/3 up the centerline of the windshield. See figure 1.

To prevent debris from entering the cockpit and cause damage that could have affected the escape system test program, a steel plate was mounted inside the windshield. This plate was removed before the last two tests. On the plate 3 plastic blocks were mounted in bushings with 3 drinking straws in each block. See figure 2. The straws are very light and the friction high, which means that when hit by the deflecting windshield they should stop at the maximum deflection without overrun. This is a very cheap method but it turned out that the friction decreased as a function of time and the blocks had to be changed frequently.

The normal force acting on the aft arc was measured by two strain gauges and the signals registered in the TM station.

The canopy has double curvature and is made of the same material 10 mm thick. The impact point was on the centerline 100 mm aft of the front arc which gave an impact angle of 22.5°. See figure 1.

In the last test when we could afford some damage to the structure, we tested a modification that has been implemented in the production aircraft after some bird strike incidents in the Air Force.

The impact angle was 17° on the centerline in the joint between the radom and the forebody. See figure 1.

In the separate bird strike tests a fully dressed dummy was used to find out the survivability should the bird penetrate the cockpit. The dummy was filmed at 500 fps by two aft looking cameras mounted behind and looking through holes in the instrument panel.

During all the tests high speed films, 5000 fps, were taken from both sides of the track showing each impact. Documentary films were taken before, during and after the runs.

PREPARATIONS

To study the behaviour of the windshiels and its attachment to the forebody at dynamic loads and at the same time get some information about deformation and strain in the acrylic, we dropped heavy weights on a windshield mounted horisontally in a mockup.

The heavy weights were lead beads in a rubber sack weighing 20, 25 or 35 kg and were dropped from various heights up to 9 m.

The strain was measured by a matrix of strain gauges in the impact area and on the arc. The deformation was measured by the before mentioned drinking straws and high speed filmed (2000 fps).

During these tests a maximum deformation of 23.8 mm was measured together with a stress of 90 N/mm², which is above the norm value. No damage was observed in the windshield or its attachment to the forebody.

BIRD STRIKE

The birds used in the tests were chickens which were killed, weighed and mounted at the exact impact point above the rails by thin nylon bands. See figure 3. Due to the rocked sled safety precautions this procedure had to take place one hour before the rocket fireing.

An idea to use drugs to keep the bird alive but unconscious was abandoned.

According to our original program we should build up the energy in steps using high speed and increasing bird weight.

In our very first test we were aiming at 35 % of the energy curve value but due to somewhat higher bird weight we god 45 % and a big surprise. The bird punched a neat hole in the windshield! See figure 4 and 5. From there on we decided to use only 1 kg (or 2 lbs) birds. Starting from roughly the same energy by using a low impact speed, the energy was increased in steps until we finally reached 100 % without any further holes.

In the last test, however, a lot of the surface was eroded away as seen in the picture figure 6.

All the test points concerning the windshield can be found in the diagram figure 7.

In the last two tests we found that the canopy although it withstood a direct hit of a 0.8 kg bird at 700 km/h, it broke as a result of the hit in the windshield. This is due to the fact that the windshield deflexion presses down the arc which permits bird mass to get under the rim of the canopy and enter the cockpit. This spray of birdmass breaks the canopy and hits the dummy. It is however shown that the dummy/pilot should survive as the inner visor of his helmet is intact. See figure 8.

It is also an experience from earlier flight tests that the absence of the canopy is noisy but survivable. In one case in the Swedish Air Force we got a hit in the canopy which showed the same result. The speed in that case was some 1000 km/h and the bird weight unknown.

The hit in the structure in front of the windshield produced a hole (see figure 9) but the bird mass was effectively stopped by the reinforcement from entering the cockpit.

A summary of the testpoints is found in the table figure 10.

CONCLUSIONS

This test method, although somewhat exclusive, is a very good tool to find the real margin. There should be no differance at all except for the kind of bird. Chickens are usually no hasard to aircraft.

The surprising result with the light bird [illegible] there can be a difference [illegible] area is small and the velocity is high. [illegible] investigate this further using the gun.

The strength of the windshield showed using 2 lbs birds agrees with the specification.

The capacity of the canopy to withstand a direct hit could not be shown but it did not breake at [illegible] km/h and a bird weight of 1.7 lbs.

It was also shown that a bird hit in the windshield could result in a broken canopy but that the pilot should be safe if he has a adequate visor down.

The modified structure in front of the windshield was effective in stopping the bird mass from entering the cockpit.

The scoop of the testing was met although some of the results need further investigation.

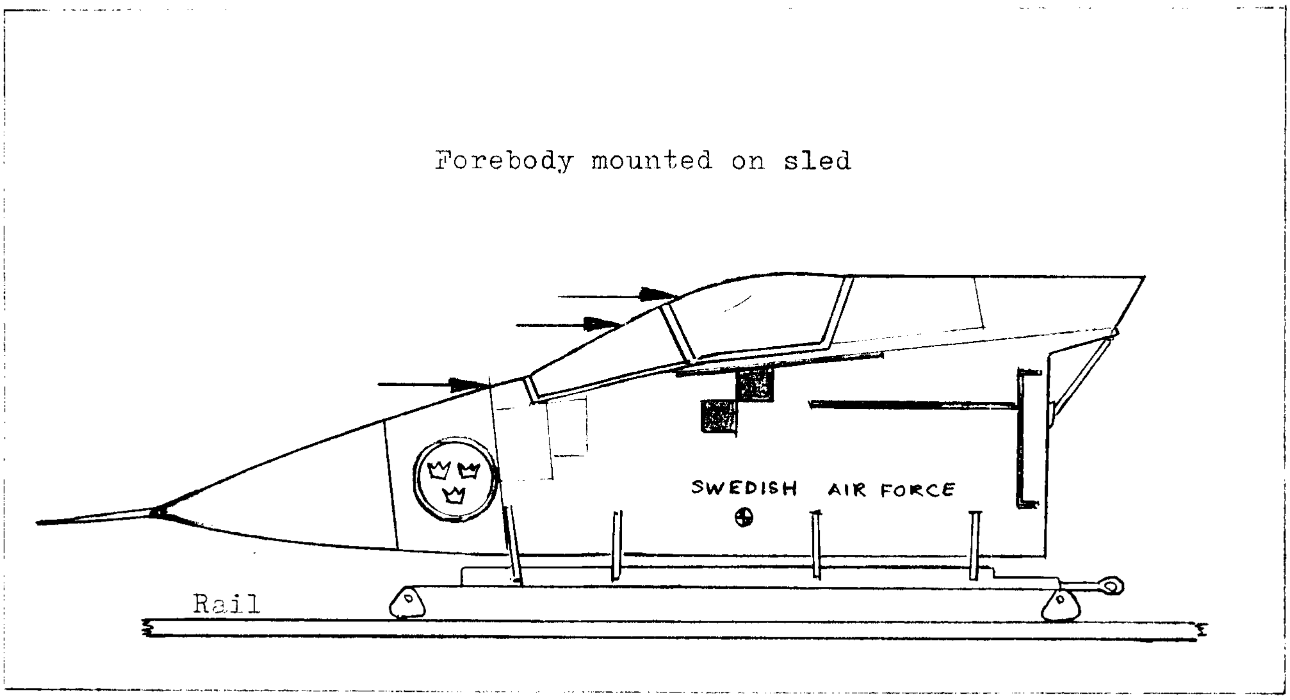


Figure 1

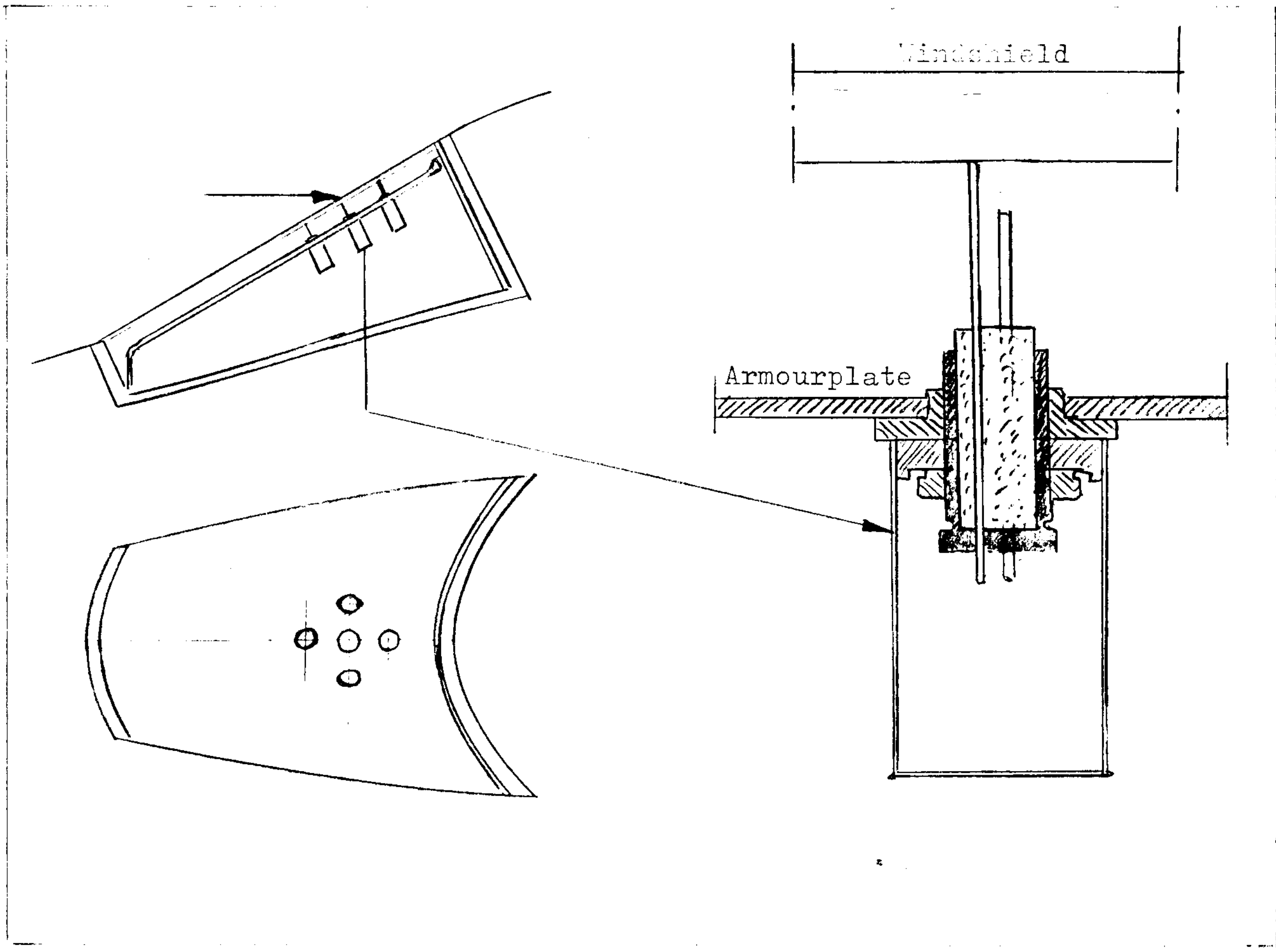


Figure 2

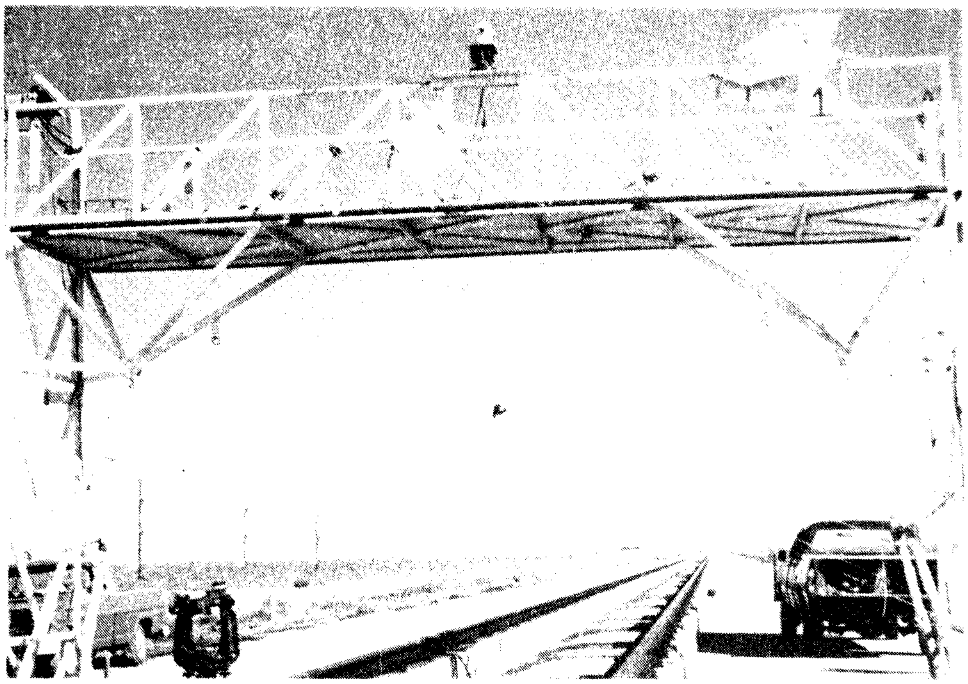


Figure [illegible]

Figure [illegible]

Figure 5

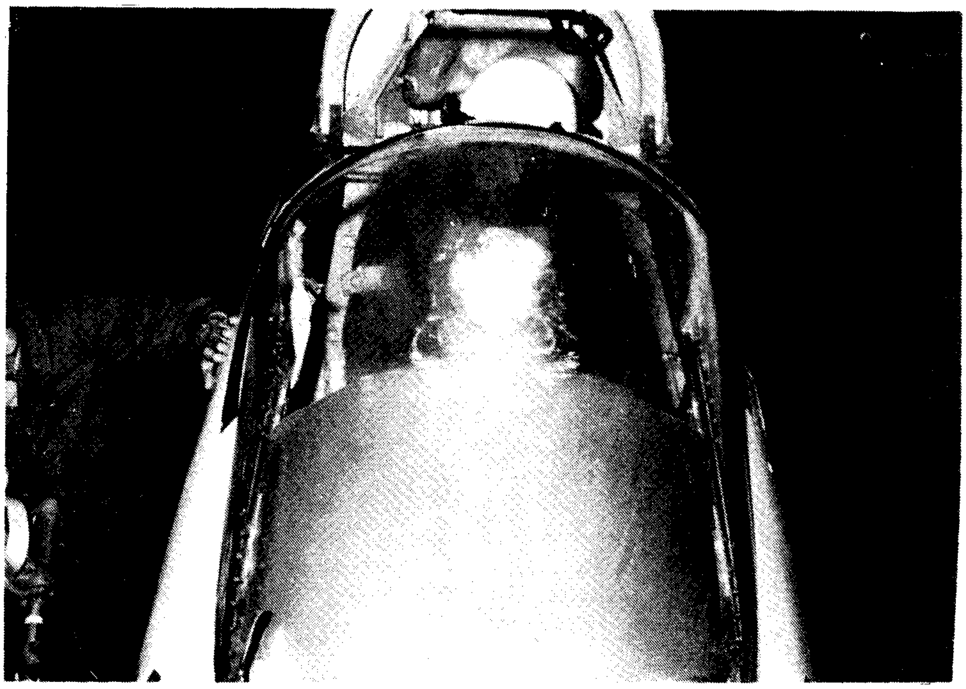
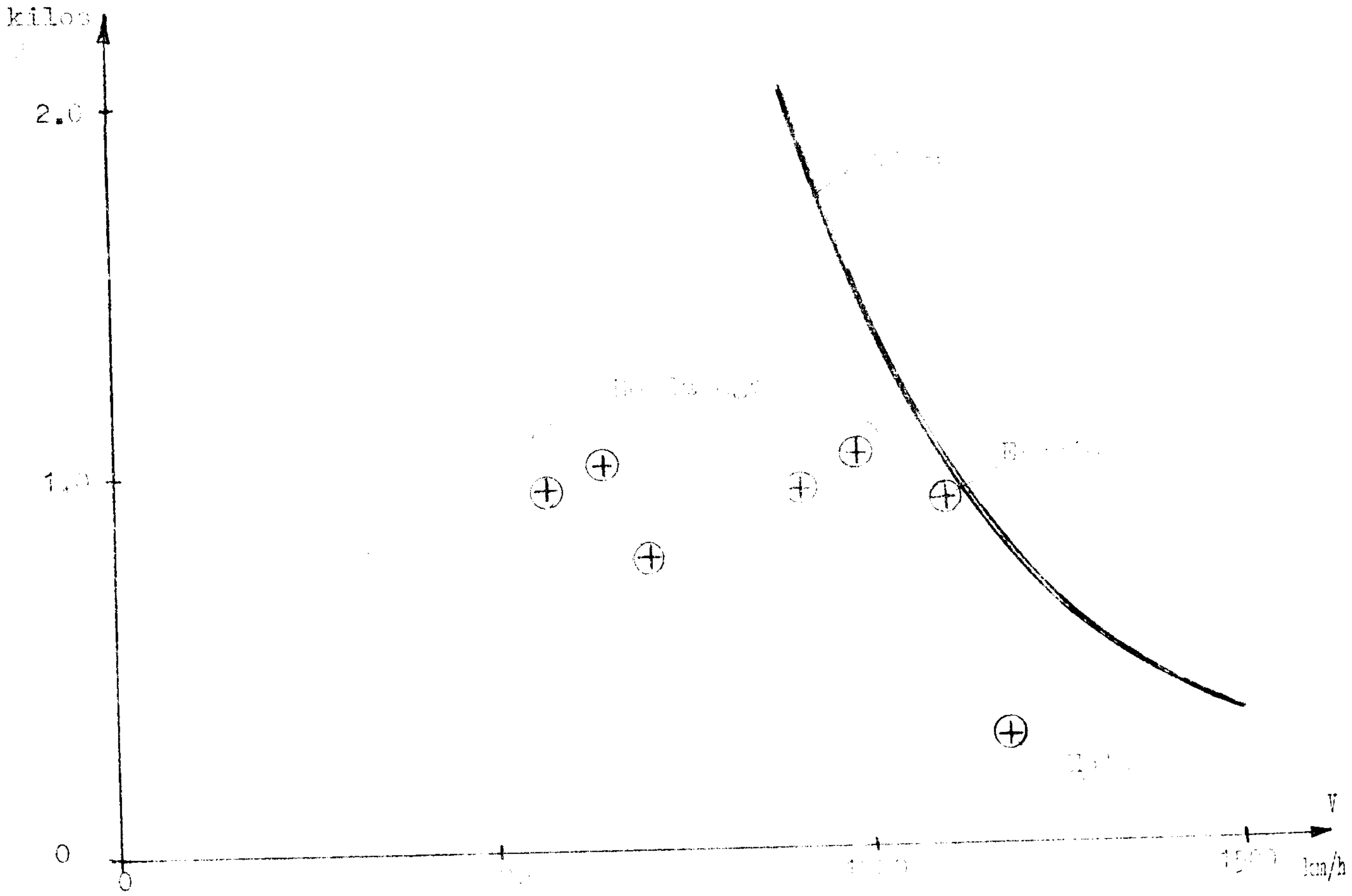


Figure 6



Figure

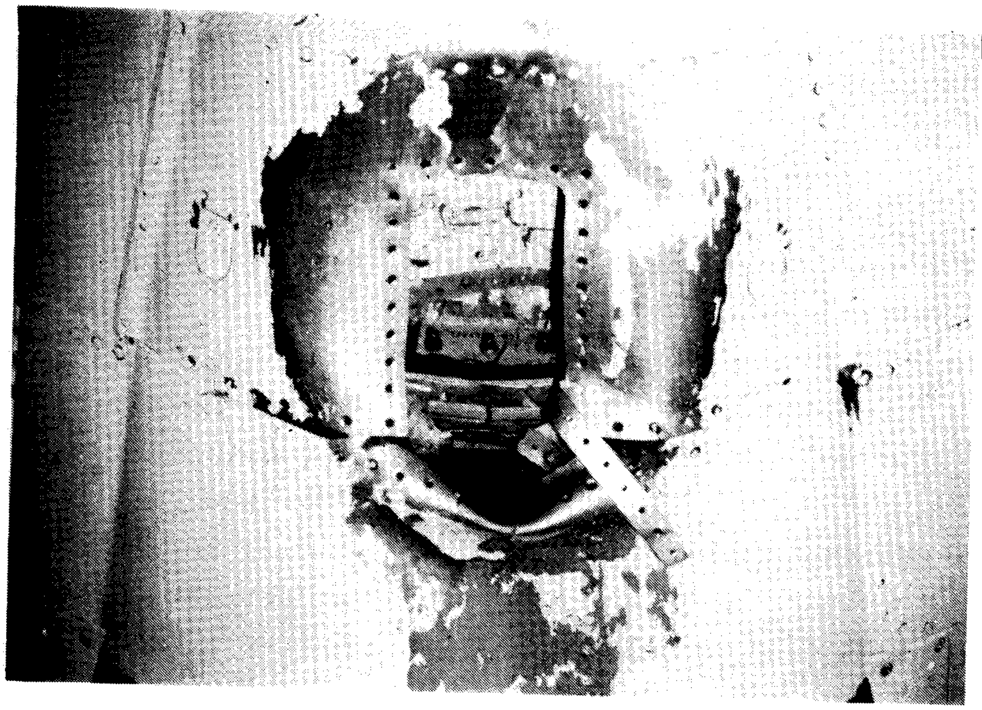


Figure 9

Run no.	Test object number	Bird weight grams	Impact speed km/h	Remarks
1	Windshield 1	289	1195	Hole in windshield
2	" 2	960	569	OK
3	" 2	1013	644	OK
4	" 2	793	705	OK
5	" 3	964	908	OK
6	" 4	1040	983	OK
6	Canopy 1	799	679	No hit
7	" 2	678	705	OK
7	Windshield 5	916	1114	Eroded surface
7	Structure	1089	1121	Reinforcement OK

Figure 10