

## Control audit report

**No. 02/GDA/07**

**STAKO Sp. j.**

Orderer : STAKO Sp.j.  
Ul. Poznańska 54  
76-200 Słupsk

Order no.: PH 102/07

Manufacturer: STAKO Sp.j.  
Ul. Poznańska 54  
76-200 Słupsk

Appliance: composite tank for compressed air  
with 1.1 L capacity

Goal: Execution of a control audit of the manufacturing process and  
control procedures for the composite tank for compressed air  
with 1.1 L capacity

Attachments: 

- cause-effect diagram
- FMEA (Failure Modes and Effects Analysis)
- schedule of improvement actions for FMEA
- control plan
- quantitative analysis of reported complaints
- complaints reports
- photo of the tank during pressure test with air under pressure  
of 300 bar
- photo of the identified defect of complained tank
- photo of cross-section of the place of setting of the aluminium  
head into the liner before and after implemented technological  
changes
- report from pressure, wear and tear tests

Date: 12-13.06.2007

Contact person: S.Kubicz STAKO  
A.Kaszczuk TÜV Nord Polska

## Control audit report

### 1. Goal of the audit.

Application correctness assessment of the production and control procedures for manufacturing of Paintball composite tanks for compressed air with 1.1 L capacity with durability tests of randomly chosen tanks.

The reason for conducting the control actions was the reported leakage of a tank during the tournament of Millennium League in Germany on 20.05.2007.

Applying for execution of the control audit is the manufacturer of the tank, STAKO Sp. j. based in Słupsk.

### 2. Introduction.

Composite pressure tanks manufactured using continuous fibre reinforcement technology are pressure appliances for operation under high pressure. Safety of the use of this type of tanks should be assured by following the design, manufacturing and control procedures, which are specified by appropriate standards and legal requirements.

Composite tanks for compressed air with 1.1 L capacity, manufactured by STAKO Sp. j. from Słupsk, mainly dedicated for "Paintball" game, are made in compliance with the EN 12245 standard and the 1999/36/WE directive.

This tank was introduced to the market in 2005, passed required official certification tests conducted by TÜV NORD and received certificate No. D-0045-320 which was issued on 6.12.2004.

The construction safety of this tank was confirmed by a series of durability tests of the materials used for manufacturing of the tank and by tests conducted within the official certification process.

The level of previously reported and recognised complaints of tanks in years 2005, 2006 and until June of 2007, caused by leakage, did not exceed the acceptable level of complaints assumed in the quality control system of STAKO.

Until the last complaint report was submitted, no corrective actions in production and control processes were made.

To answer the question why, the tank leakage occurred while it was being used, STAKO sp. j. ordered the certifying unit TÜV NORD to execute a control audit of the tank's production and control processes.

### 3. Audit program.

- a. Examination of the production process and associated control procedures,
- b. Examination of the complained tank and fault analysis leading to determination of their root-cause,
- c. Evaluation of the validity of modifications implemented into the production process,
- d. Examination of the tank from the production batch of 200 tanks – standard procedure,
- e. Fatigue examination of the tank – In order to validate correctness of the design,
- f. Preparation of the final report.

#### 4. Report of conducted actions.

Inspection of the manufacturing records of 1.1 L composite tanks did not show deviations in the production process. Specified control procedures for technological operations and acceptance procedures for the batch of manufactured tanks were realized in accordance with the technological process and the requirements of the EN 12245 standard.

Technological instructions for every step of manufacturing were available at workstations and instructions contained within the control plan were being followed.

Before the inspection visit of the TÜV NORD representative, STAKO conducted their own tank tests, on the basis of which, they conducted FMEA of potential reasons which may cause leakage formation in tanks.

In order to conduct the analysis STAKO prepared a cause-effect chart, analysing all process elements resulting from human activity, material or method - the manufacturing process, the system in which the process is realized, and the appliances participating in the process.

The chart listed the possible situations affecting the possibility of leakage formation, then, this chart and schedule of improvement actions were used to prepare the FMEA, which specified the effect of improvement actions on the quality of the product. The studies mentioned above were presented to a TÜV NORD representative during the audit and were enclosed with the audit report.

During the audit, two manufactured tanks and the tank the complaint concerned were examined.

- From batch 703 of manufactured tanks, tanks with numbers 3669 and 3502 were randomly chosen.

Tank no. 703/3669 was visually examined, and subsequently a water pressure test with pressure 450 bar was conducted. After a positive air-tightness test, the tank was put to a fatigue test with application of variable loads in 5000 cycles in range from 2.5 to 450 bar (STAKO increased the demands of the test raising the upper pressure from 300 to 450 bar). After the tank passed the test, it was put up for a burst test.

The test was stopped at a pressure of 1150 bar without having the tank burst, in order to protect the installation. The required pressure, which a tank should endure, is 900 bar. The result was regarded as positive.

- The second tank no. 703/3502 was put to the test for torsion of the tanks neck with the torque with value of 150% those admissible by STAKO.

This tank positively passed both the underwater pressure test and the air tightness test. Subsequently it was put to a fatigue test with application of variable loads in 1000 cycles in range from 2.5 to 450 bar.

After the tank passed the test, it was submitted to an air pressure test with pressure 300 bar. Test ended positively, no leakages in the tank were found.

- The tank the complaint concerned 648/2457 was put up for water pressure test with pressure 450 bar, which displayed leakage (explicit leak from the region of the setting of the aluminium head into the liner). The exact point of the leak was impossible to locate, because the place from which the leak was emerging was under carbon fibre wrap, not necessarily opposite the place of the crack in the liner.

After cutting the tank and removal of the carbon fibre wrap, the location of the crack was not visible.

In the region of the head's neck at the point of contact of the liners material and aluminium element there was local thinning of the plastic layer (photo attached)

## 5. Conclusions of the executed audit.

The executed examination of production process, control process and acceptance process of 1.1 L composite tanks did not display any infringements. All tests verifying the quality of composite tanks manufactured by STAKO Sp.j. were passed positively.

During the inspection, no explicit cause of leakage of tanks revealing itself during exploitation was established. The place, which could be at risk of cracking, because of variable loads when the tank is being filled or emptied, was the region of the neck of the head at the point of contact of the liners material and aluminium element.

Because of repeatability of forming the plastic layer in the form, no explicit reason of inequality in plastic coating at the point of the contact of the liner with the aluminium element was pointed.

In FMEA STAKO presented the factors, which could have a potential effect on formation of leakages in the tanks.

STAKO implemented the recommended improvement actions listed in FMEA into production process.

After implementation of changes thermoplastic liners and finished tanks were manufactured, and STAKO conducted production tests on them.

Performed actions did not display differences in the quality of manufactured tanks, because examination results before and after implementation of changes in the production process were consistently positive.

Changes of production process suggested in FMEA were introduced by STAKO permanently into the tank manufacturing technology.

As a result of the executed audit TÜV NORD representative stated, that STAKO sufficiently fulfilled the efforts needed to detect possible reasons which might induce single incidents of tank leakage and introduced improvement actions into the production process basing on FMEA.

Resuming production of mentioned tanks, which was suspended on 22.05.2007 by Quality Assurance Team until analysis of the production and control system, construction of the liner with a set aluminium head element, as well as finished tank, during production period following introduction of changes in technological process, should be covered with increased level of control, in order to determine the effect of changes on the increase of the tank operation safety.

Because of that, the TÜV NORD representative recommended, especially in that period:

- introduction of additional changes into the composite tank control plan in operation no 140 pos 79-82, with regard to detection of the liner faults, which could affect the tank operation safety, with additional control of quality control division,
- introduction of internal endoscope inspection of the point of contact of the liners neck with the aluminium head element,
- covering the control regarding quality and portioning of plastic for tank production with the activities of quality control divisions.

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