

Kawasaki Heavy Industries, Ltd.

February 28, 2018

Notice of Series N700 Shinkansen Train Bogie Frames matter

Kawasaki hereby reports on the above matter, as described in the attached documents.

It is still not clear how far this matter will affect business performance; however, should matters requiring disclosure be identified, you will be notified promptly.

Series N700 Shinkansen Train Bogie Frames

With reference to the crack (structural failure) of the bogie (or truck) frame (hereinafter referred to as the "Failed Bogie Frame") of series N700 Shinkansen train owned by West Japan Railway Company (hereinafter referred as "JR West") occurred at Nagoya Station on 11 December 2017, we, as the manufacturer of the Failed Bogie Frame, hereby express our sincere apology for inconvenience and concern caused to passengers of Tokaido-Sanyo Shinkansen, JR West, Central Japan Railway Company (hereinafter referred to as "JR Central") and any other related party.

While the Japan Transport Safety Board (hereinafter referred to as "JTSB") is currently conducting dedicated investigations into a root cause of the crack of the Failed Bogie Frame, we hereunder report what has been revealed in the investigation until now and our remedial actions to be taken.

1. Results of the investigation of the Failed Bogie Frame and defects during manufacturing process

We manufactured the Failed Bogie Frame in February 2007 at Kawasaki's Rolling Stock Company Hyogo Works, and the followings have been revealed in the investigation until now.

- (1) Although the bottom plate of the side frame of the bogie frame of series N700 Shinkansen train should be 8mm thick the design specifications (more than 7mm post-processing), it is 4.7mm at the thinnest location. The results of our internal investigation reveal that in order to adjust the gap between the side frame and the primary spring seat during the welding assembly, the uneven bottom plate of the side frame was excessively ground off, resulting in thinner than 7mm.
- (2) The results of the investigation by the Railway Technical Research Institute showed that, although the surfaces of initiation area of the structural tear by contacts, the detailed investigations suggest a fissure caused by some factors including the welding process.
- (3) Traces of deposit welding resulting from dimensional adjustments to compensate displacement in dimension by excessive grinding-off were also observed across the entire surface of the primary spring seat close to the crack. Deposit welding is a method generally used for repairs. Although this area with deposit welding should have undergone a process relieving residual stress, any record of stress relief process is not found and it is suggested that the endurance limit of the side frame matrix around the primary spring seat might be affected.

2. Investigation of series N700 train bogie frames manufactured by Kawasaki other than the Failed Bogie Frame

With cooperation from JR West and JR Central, we have, since 26 December last year, conducted investigations on the bogie frames for series N700 Shinkansen train manufactured by Kawasaki other than the Failed Bogie Frame by means of ultrasonic searches for flaws in the areas where the crack occurred on the Failed Bogie Frame.

Ultrasonic testing can detect any existence and size of internal microscopic flaws which cannot be detected through visible inspection.

- (1) It is found that the bottom plate of side frame is thinner than 7mm on 146 bogie frames in total, including 100 of JR West and 46 of JR Central respectively, beside the Failed Bogie Frames.
- (2) The ultrasonic testing suspected internal flaws in 29 bogie frames in total, 22 of JR West and 7 in JR Central respectively. When 10 of them were cleaved to investigate the details, all 10 bogie frames were confirmed to have internal flaws. All the confirmed internal flaws were confined to the welding area between the side frame and the primary spring seat, and do not have any adverse implication to the strength of the bogie frames.
- (3) Deposit welding across the entire primary spring seat has not, at this point in time, been observed on any bogie frame other than the Failed Bogie Frame. Nevertheless, investigations are still ongoing.

3. Background and causes of the defects during manufacturing process of the bogie frame including the Failed Bogie Frame

The causes and background why the thickness of the bottom plate of the side frame did not conform to the design specification and such bogie frames were installed to the trains and delivered to JR West and JR Central regardless of our in-house inspections are as follows.

- (1) According to the work procedures dedicated to the series N700 bogie frames, the side frame and the primary spring seat should be assembled together by welding after the gap between them is adjusted to no more than 0.5mm as target (allowable tolerance up to 1mm or less), and the side frame shall not be ground off. However, the following background and reasons as to why those procedures were not strictly adhered during the manufacturing of the series N700 bogie frames have been identified.

- ① There is inconsistency (although it is within tolerance) in the precision of the press-bended bi-parting parts for the side frame, which is outsourced, and the bottom plate of the assembled side frame might not be even. There was therefore an adjustment task required involving the side frame and the primary spring seat. This situation was caused by shortcomings in our quality management system of outsourced parts.
 - ② Although the side frame shall not be ground off, the foreman wrongly applied the criteria for welding finishing we follow (equivalent to the finishing method of the bogie parts stipulated in the current Japan Association of Rolling Stock Industries standard JRIS W 0305 (2011), whereby the matrix around the welding bead may be ground off by up to 0.5mm. In addition, when the foreman instructed the workers to make adjustments so that the gap between the bottom plate of the side frame and the primary spring seat, he failed to remind that the side frame shall not be ground off by more than 0.5mm. As a result, the degree of grinding off was not uniform, owing to the precision of the press-bended bi-parting parts of the side frame. The foreman also did not check the actual conditions of the side frame after processing.
- (2) Through the investigation in (1) above, the following deficiencies have been identified in our quality management system.
- ① The work instructions issued from the production engineering office of the Manufacturing Department were vague and many aspects of work processes were left up to the site chiefs and the foremen. In order to supplement these vague instructions, the work was carried out in accordance with the work criteria and work procedures. However, training and education were also left up to the site chiefs and the foremen, and records of training and education were not properly made.
 - ② There was a lack of clarity about discretion at the shop and the delegation of authorities and responsibilities. The production engineering office of the Manufacturing Department did not confirm the actual performance at the shop after the work instruction is issued.
- (3) The thickness of the cracked area of the Failed Bogie Frame was not included in either the quality control points set out by the Quality Assurance Department, or the self-inspection points set out by the Manufacturing Department. As a result, the thickness of the side frame of the Failed Bogie Frame was not checked before the complete train with the Failed Bogie Frame was delivered to JR West because the grinding off of the side frame matrix was never foreseen, although the in-house inspections regarding complete bogie frames are conducted at 248 points for bogie frames for powered cars, and 208 points for bogie frames for trailer cars respectively.

4. Possible root cause of the crack of the Failed Bogie Frame

Through the investigations, analysis and modeling until now, it is considered that a fissure caused by some factor including the welding process existed. This fissure as a trigger point propagated faster by effects of the thinner bottom plate of the side frame and developed the crack of the Failed Bogie Frame. Also there is a possibility the deposit welding across the entire primary spring seat gave an adverse implication.

The detailed investigation of the Failed Bogie Frame is still ongoing under the supervision of JTSB to identify a root cause and a propagation mechanism of the crack. We will cooperate in the investigation on every level and will continue to dedicate the utmost effort to it.

5. Recurrence prevention measures

We have implemented upgrading of quality assurance regime, including strengthening quality education for shop workers, documenting the knowhow of the site chiefs and the foremen who supervise and have responsibility for manufacturing at the shop, and reviewing the quality management system for outsourced parts (including press-bended bi-parting parts for the side frames). In addition, we will restructure our quality management system and are making every effort to ensure the prevention of recurrences. While the root cause of the crack of the Failed Bogie Frame has not been identified, we are implementing the following measures in the interim.

- (1) The Quality Supervision Committee (provisional name) has been established, headed up by the president of the Rolling Stock Company. This committee will review areas such as the inspection points set out by the Manufacturing Department, and the inspection points set out by the Quality Assurance Department, and will reinvestigate and resolve issues and concerns relating to manufacturing and quality management. Utilizing the knowledge of external specialist organizations and Aerospace Company and Corporate Technology Division of Kawasaki, we will establish systems to prevent any product not conforming to the drawings and the work procedures from being delivered to the customers.
- (2) The check points set out by the Quality Assurance Department for the manufacturing process for a first article will be increased. The quality management system for the follow-up inspections to subsequent productions will be strengthened. In addition, the Quality Control Department will be newly established within the Manufacturing Division and will work to refresh the content of training and education for shop workers, supervise documentation including the work procedures, and check actual work processes.

- (3) We will adhere strictly to the Kawasaki Production System (our activity to establish shop rules that safeguard standardized working practices; practices that ensure the same quality is achieved, whoever does the work, so that consistent quality can be secured), and aim to secure quality through standardization, education and transfer of skills, observance of shop rules, and through increasing strength in the shop. [currently ongoing]

We are refocusing on ensuring that information which has implications to design and quality is communicated thoroughly. At the same time, we will ensure again that the employees are conscious of the fact that we are supplying rolling stock to railway operators and that the safety is the absolute priority, and will ensure that every employee has an even higher awareness of the significance of each task they perform, and that they work to manufacture rolling stock with a sense of public interests.

6. Bogie frames on other rolling stock

With regard to bogie frames for Shinkansen trains and conventional trains in Japan and overseas other than the series N700 Shinkansen train, we have reconfirmed that the work in the Manufacturing Department is being performed according to the work procedures through the quality confirmation instruction (checklists), and it has been confirmed that the work is being implemented in line with the drawings and the work procedures.

7. Remedial actions

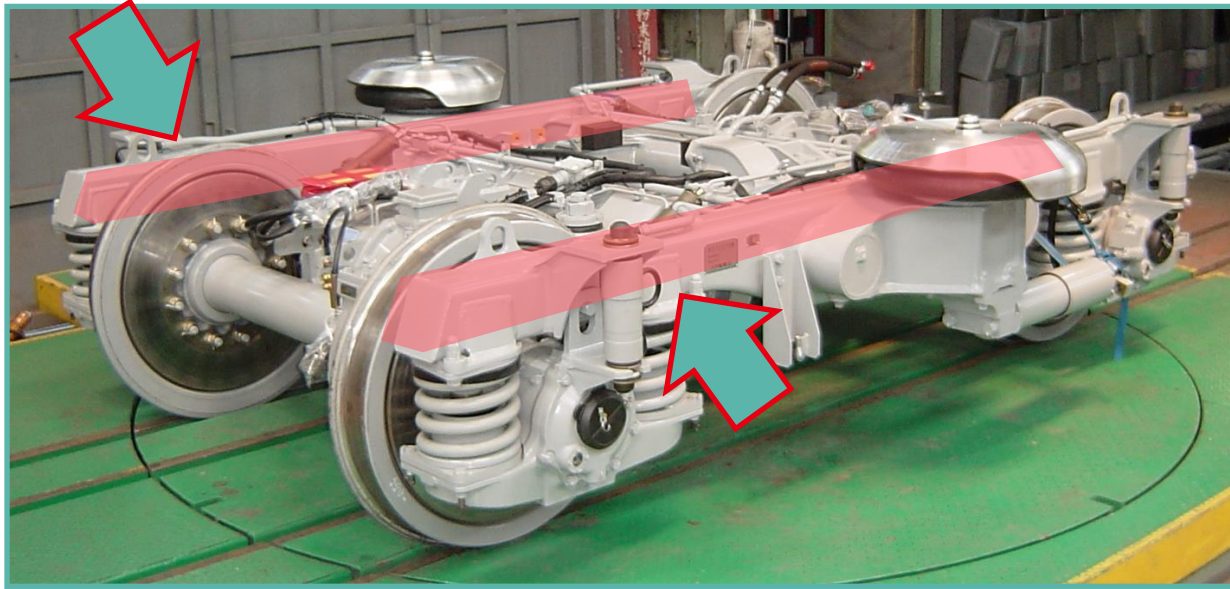
- (1) Regarding the series N700 bogie frames that we manufactured to the same specifications as the Failed Bogie Frame, we will replace the bogie frames with thinner the bottom plate of the side frame less than 7mm in thick with new ones. We will also replace the bogie frames where, as a result of ultrasound testing, there might exists an internal flaw in consideration of our defects during manufacturing process.
- (2) The president of Kawasaki has instructed thorough investigations and checks to be carried out in every company of Kawasaki to ensure that the work procedures developed on the basis of technical requirements are being adhered definitively, and that no products are being produced where a local decision has been made to deviate from the work procedures. Furthermore, the Quality Supervision Committee (provisional name) has been established to ensure these measures are rigorously implemented across the Kawasaki group by utilizing observations and views of external specialist. The entire Kawasaki group will continue working together to implement robust measures for quality management.

Explanatory Material for Manufacturing of Bogie Side Frames for Series N700 Shinkansen

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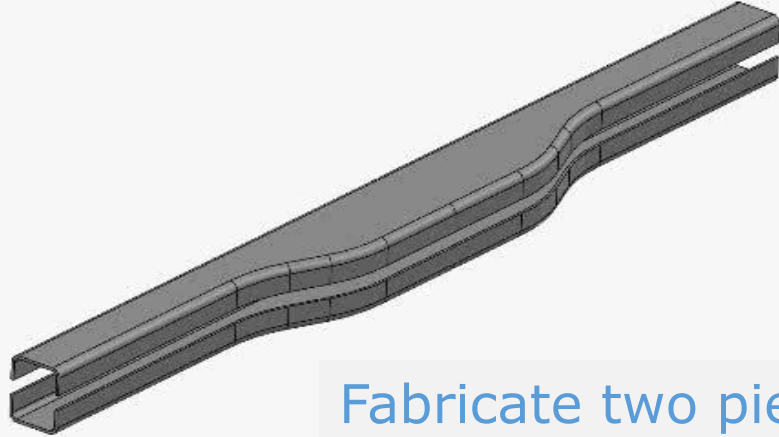
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Manufacturing Process for Series N700 Bogie Side Frames

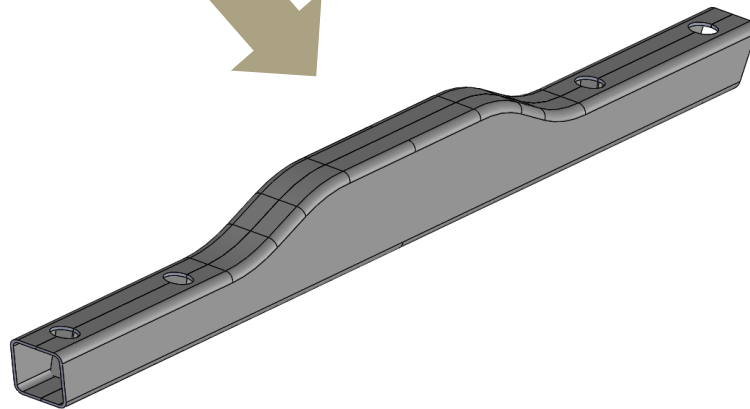


- There are two side frames in a bogie.
- They are the structural parts which support the car weight on the axles.

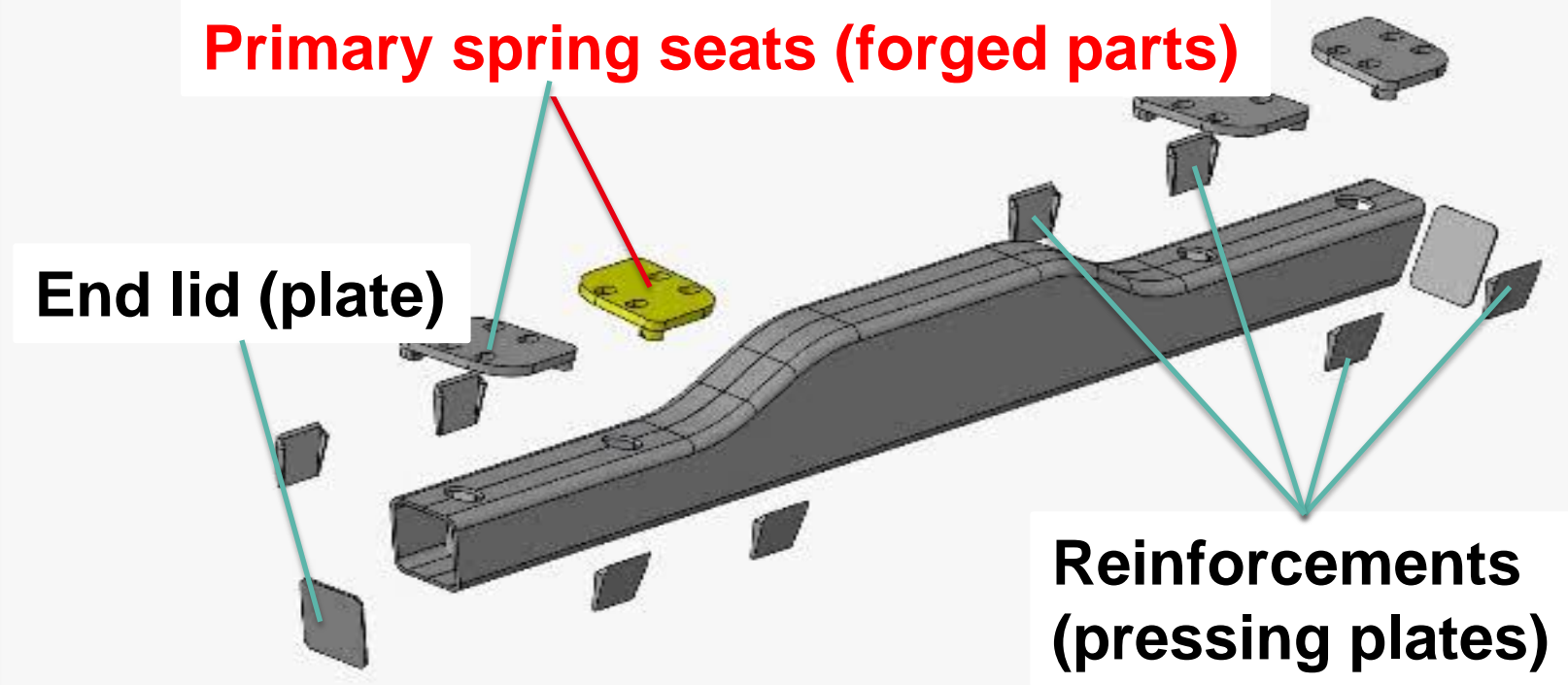
Welding Fabrication of Side Frames



Fabricate two pieces by welding

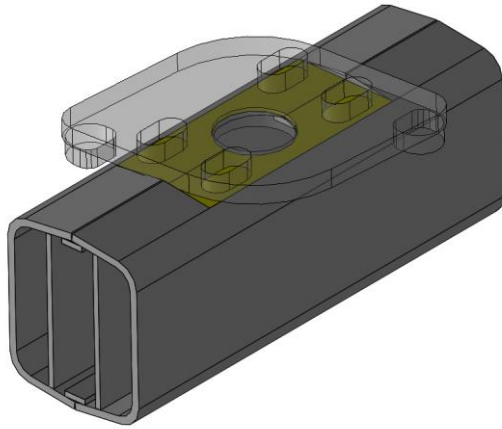


Welding Attachment of Parts to Side Frames

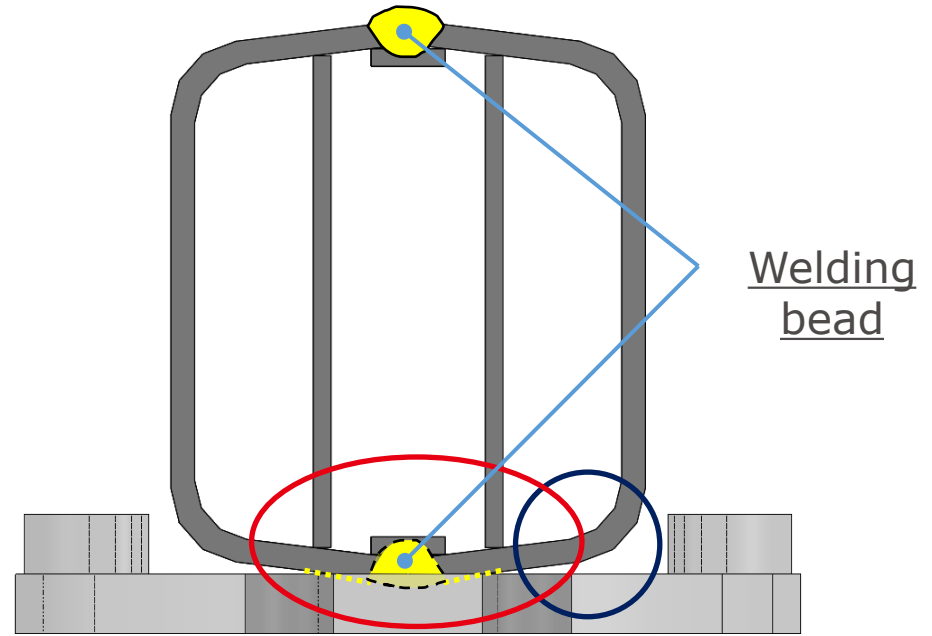


Defects in Adjustment Work during Attachment of Parts to Side Frame

When the primary spring seats were attached, the bottom plate of side frame was not even and was ground off to adjust the gaps between the side frame and the primary spring seat to 0.5mm.



Area of adjustment



Cross-section image of the primary spring seat attached section

As a result, the side frame became thinner.