Types and Functional Requirements of Railway Fasteners

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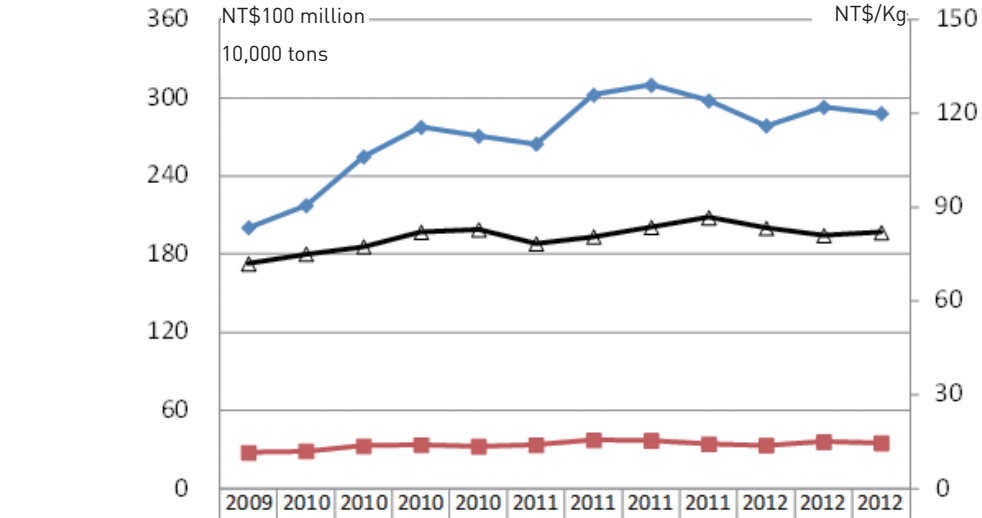
The railway is well connected to the transportation of the entire society. As the construction of a railway transport system usually requires a large-scale investment and the engineering procedure including basic construction, business operation, and the purchase of equipment is very sophisticated, it is closely related to several industries. A railway system is composed of steel rails, fastening elements, railway ties, and ballast, among which fastening elements are an important sub-system (i.e. clips, elastic base plates, and anchors) to support the railway. Each unit of the sub-system comprises different components with certain physical and chemical properties. Clips are used to hold rails onto the base plates in order to prevent the train from derailing. Currently, most important components used on the railway of Taiwan were imported from other countries. In order to improve the performance of the railway system and reduce the cost for railway maintenance, Taiwan Railways Administration (TRA) is active in promoting the development of domestic railway industry. Furthermore, with the addition of other metro and high-speed rail systems, the demand for railway fasteners will be increasing day after day.

Table 1 and **Figure 1** both show the fastener industry is one of the important metallic product manufacturing industries in Taiwan. Its industrial cluster and sophisticated labor division established in the past few years make it not second to the IT or other high-tech industries in terms of the competitiveness in product quality and lead time.

In the fastener industry, the development of railway fasteners is going to be high added value oriented, in response to the advancement of railway industry and the construction of high speed rails, metros, and light rails. Railway fasteners act to prevent the rails from unexpected separation when the train passes through. A rail fastener usually comprises a steel shoulder, a rail pad, an insulator, etc. Taiwan has been engaged in the improvement of railway engineering and focuses on the R&D of a railway system that is “safe, durable, in low maintenance cost, with high economic efficiency, and with low environmental pollution.”

Table 1. Statistics of Exports of Taiwan Transport Systems and Part Manufacturing in 2012

Year	2008	2009	2010	2011	2012
Value (NT$ million)	70,349	60,343	60,109	49,836	46,369
Annual growth rate (%)	20.11%	-14.22%	-0.39%	-0.1709%	-6.96%
Percentage (%)	0.92%	0.95%	0.73%	0.58%	0.55%



	2009 /Q4	2010 /Q1	2010 /Q2	2010 /Q3	2010 /Q4	2011 /Q1	2011 /Q2	2011 /Q3	2011 /Q4	2012 /Q1	2012 /Q2	2012 /Q3
Export value (NT$100 million)	201	218	255	278	271	265	302	310	298	279	293	288
Export volume (10,000 tons)	28	29	33	34	33	34	37	37	34	33	36	35
Export unit price (NT$/Kg)	72.1	75.1	77.5	82.1	82.9	78.4	80.7	83.7	86.8	83.4	81.1	82.0

Figure 1. Statistics of Taiwan Fastener Exports from Q4 2009 to Q3 2012

Source: Taiwan Customs import and export data of Taiwan Institute of Economic Research, compiled by MII-ITIS of MIRDC

The fastening system can be categorized into 3 following types-

(1) **Concrete Cross Tie**- Rails can be fitted onto concrete cross ties with in-between flexible rail pads, which is for insulation.

(2) **Wood Cross Tie**- Metallic base plates have to be placed between rails and wood cross ties in order to protect the wood cross ties and provide a larger area to support the rails.

(3) **Direct Fixation Fastener (DFF)**- Only spring clips need additional flexible components except for others. The fastening system is usually designed according to the vibration reducing capacity of the roadbeds.

The main function of the fastening system is to provide a connective force to fixedly hold the rails. The formation of such a force is generated from the tensile of installing railway fasteners. As rails will be displaced when there is excessive longitudinal, transverse, or vertical force resulted from the passing through of a train, railway fasteners must be used to avoid effects of these forces. In addition, the fastening ability of a railway fastener is determined by its size, shape, and material used.

Types of Properties of Railway Fasteners

Common railway fasteners used in the market show a variety of forms and shapes. They are assembled with other components as independent units, which can be fixed onto the rails as a whole, and which can offer under controlled vertical, longitudinal, and transverse forces to avoid excessive displacement. Different types of railway fasteners cannot be replaced with each other. They can be categorized into 3 types by their usage-

(a) **Spikes**- often used onto wood railway ties, including hook spikes, threaded spikes and flexible spikes.

(b) **Bolts and wedge shaped fasteners**- Wedge-shaped fasteners are fixed onto rails and fastened with bolts. They are fixed together on prepared parts or anchoring threaded bases.

(c) **Spring clips**- Anchors and shoulders are pre-cast inside the base plates or the track supporting system; then, flexible steel rods are used to fix them. They can be categorized by feature-

(1) **How they are fixed**

(2) **Appearance**

(3) **Longitudinal resistance**

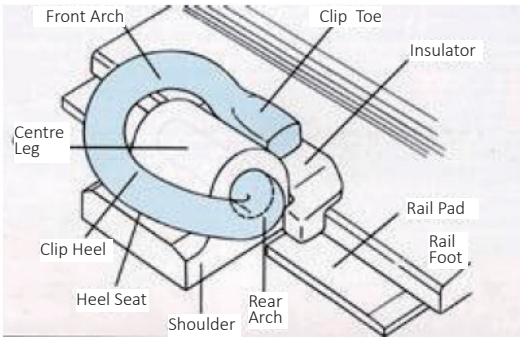
(4) **Flexibility**

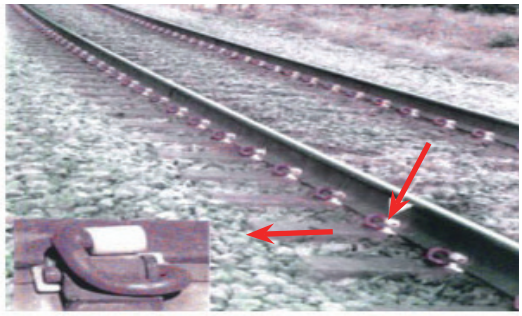
Table 2. Types of Fasteners Used in Certain Countries

How They Are Fixed	Appearance	Names of Fasteners Used
Bolt Type	Steel Bar	Germany- Vossloh W type
	Steel Plate	France- Stedef Nabla fastener and RN fastener
		Japan- 102 type fastener
	Steel Block	Germany- K type fastener
Non-Bolt Type	Steel Bar	UK- Pandrol e type fastener, PR type fastener, and FastClip
		The Netherlands- DE fastener
		The US- Sidewinder fastener
		Switzerland- Fist fastener
		Sweden- Hambo fastener
	Steel Plate	Australia- Mc Kay Safelok
		UK- Pandrol Safelok III
		Australia- Rex-Lok

Pandrol International Limited is a company in UK and has been famous for its railway fastening systems since 1937. Its fasteners are generally referred to as Pandrol fasteners, which include e type fasteners, PR type fasteners and FastClips. **Figure 2** illustrates Pandrol e type fasteners, which can

Figure 2. Pandrol e Type Fasteners





be easily installed and maintained. Hence, they are widely used in the main railways of Taiwan.

Given that fasteners have many types, trains going safely on rails, convenient maintenance & repair, material durability, and possibility of fatique, requirements in fastener design including proper loading and performance must be taken into account. If a certain material is not strong enough, its structure must be modified or another material should be used. Rail fasteners should be made of alloy spring steel that meets UK standards (BS970 PART2: 1988 grade 251 A58), JIS G4801 SUP9 or other applicable standards. In Taiwan, rail fasteners should meet CNS 2905 and should have a certain level of rust resistance; in addition, they should undergo heat treatment. 20 items out of 50,000 fasteners would be selected at random to undergo the following lab tests.

1. **Dimensional Check-** based on appropriate dimensional diagrams.

2. **Content Analysis-** Content of either phosphorus or sulfur should not exceed 0.035%.

The type of spring steel used to make fasteners should have a proper level of metal fatigue life, can withstand impacts and will not deform easily. Suitable steels of this kind include carbon steel, Si-Mn steel, Si-Cr steel and SUP7/SUP9 types of steel specified in JIS G4801. **Table 3** illustrates the specific contents of each rail fastener.

Table 3. Specific Material Contents of Certain Grades of Rail Fasteners

	C%	Si%	Mn%	P%	S%	Cr%	Ni%	Mo%
Grade BS970-5 805A60	0.55-0.65	0.10-0.35	0.70-1.00	-	-	0.40-0.60	0.40-0.70	0.15-0.25
Grade BS970-5 925A60	0.55-0.65	1.70-2.10	0.70-1.00	-	-	0.20-0.40	0.20-0.30	-
JIS G4801 SUP 9	0.50-0.60	0.15-0.35	0.65-0.95	<0.035	<0.035	0.65-0.95	-	-
JIS G4801 SUP 9A	0.55-0.65	0.15-0.35	0.70-1.00	<0.035	<0.035	0.70-1.00	-	-

3. **Hardness-** should be 44 to 48 HRC (Rockwell hardness).

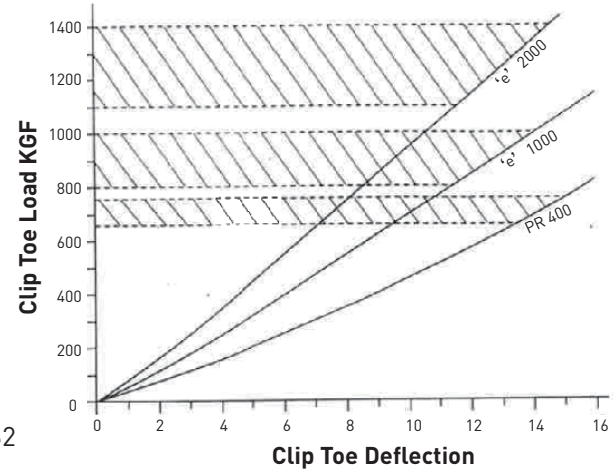
4. **Toe Load of Fastening-** should exceed 750 Kgf when the displacement reaches 12.7 mm.

5. **Fatigue Test-** Among the 20 items randomly selected in each group, the fasteners with the highest toe load of fastening should undergo the metal fatigue test: the fastener should undergo 3 million times of 12.3 mm displacement. The relaxation rate should not exceed 5%.

Fastener Clips are components that have to withstand the force created when a train runs over the railway. In order to prevent derailing, fasteners must provide enough fastening strength, which is an important indicator. **Figure 3** is a graph illustrating the clip toe deflection for Pandrol e type fasteners and PR type fasteners. When a train runs faster on the tracks, a bigger force will be exerted. Therefore, how to increase the fastening strength has become a focus of research. Because fasteners are closely correlated with safety, older types of fasteners should be maintained periodically or be replaced. As of now, newer types of rail fasteners are developed towards higher levels of safety as well as ease of installation and maintenance.

Figure 3. Clip Toe Deflection

Clip Series	Bar Diameter mm	Approx. Clip Weights Kg	Toe Load Kgf
'e' 1200	12	0.18	200-400
'e' 1400	14	0.30	400-600
'e' 1600	16	0.44	500-700
'e' 1800	18	0.59	800-1000
'e' 2000	20	0.76	1100-1400
PR 80	12.7	0.25	250-350
PR 100	15.9	0.50	350-450
PR 200	17.5	0.69	450-550
PR 300	19.0	0.84	550-650
PR 400	20.0	1.00	650-750
PR 600	22.2	1.23	800-1000



Conclusions

A complete railway network will be formed in Taiwan as more underground railway systems, rapid transit systems, light rail rapid transit systems and high-speed rail systems have been and will be constructed. Such a railway network is a correct approach for Taiwan to catch up with the industrial countries and will also assist the economic development and competitiveness. In addition, as high-speed railways, rapid transit systems and light rail rapid transit systems are being constructed, the demand for electrical/mechanical components and fasteners is on the rise. Therefore, this will pose a great business opportunity for the relevant industries. Taiwanese government has explicitly pointed out that the development of transport systems with tracks will be the focus of the future, which offers great business opportunities from purchasing, renewal, and maintenance. If the relevant industries can grasp the opportunities, it will be favorable to speed up the development of the railway industry.

The railway industry is highly technology-intensive and capital-intensive. It requires substantial investment and a long period of time for return. It is also of high values and can act as a locomotive to drive up the relevant industries and improve the transport systems of Taiwan. Therefore, the railway industry may have big, positive impacts on the development of economic structure. Moreover, the railway industry is one that any developed country should focus on and utilize to upgrade its industries, and so is for the developing countries. However, there should be long-term plans and guidance to establish a solid base. That is why lots of countries continue to offer sufficient and long-term support to facilitate the development of its railway industry.

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