# WORKFORCE INFORMATION DATABASE AND RFID TECHNOLOGY TO TRACK AND MANAGE WORKFORCE INFORMATION

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**ABSTRACT:** Workforce information is important in production planning because production planning requires matching a production unit's capacity to loads of assignments. However, tracking and managing workforce information such as skills and accident history is not an easy job. This paper describes a prototype database system for a workforce database system that employs RFID technology. This system tracks daily workforce production capacity on sites. A pilot project is described to explore the benefits and possibility of using radio-frequency identification (RFID) to track and manage workforce information, and is followed by the results of a survey to identify benefits. In addition to the survey identifying the benefits of the database system, the paper also presents a list of challenges through a series of interviews.

*Keywords: Workforce information database, Radio-frequency identification (RFID) technology, tracking, Production planning, Construction management*

## 1. INTRODUCTION

Contractors deal with several formidable tasks during construction. One of the important challenges is project control. Effective project control involves a multitude of tasks including procurement management, cost management, schedule management, quality management, production planning/control, and safety management. Among those tasks, production planning has received attention in that it is a lowest level of planning which gives direct order to workforce.

Workforce information is important in production planning because production planning is a job matching a production unit's capacity to loads of assignments [1, 2]. However, tracking and managing workforce information, such as the level of workmanship and accident history, is not an easy job in that the construction industry has high turn-over rates. The need for data entry and management at the project level is a major obstacle to the success of a system [3]. If a project size is large, tracking workforce information takes immense time and efforts. The paper proposes to use radio-frequency identification (RFID) technology to track and manage workforce information, specifically for frontline managers to use for their production and safety planning and control.

This paper presents a case study where RFID technology coupled with workforce database system was used to track and manage workforce information. It also reviews literature on applying RFID to construction. The system architecture of the suggested system is described, followed by description on implementation of the system with an example. The paper also presents the potential benefits and challenges from the suggested system.

It is noted that the system described in this paper covers only what and how the information on workforce is tracked and transferred to the computerized project management system. The study on how such information is utilized in the planning is still under development.

## 2. RFID AND ITS APPLICATION TO CONSTRUCTION IN LITERATURE

RFID is one of important automatic identification techniques currently being used in many industries such as manufacturing. The RFID tag is a small wireless computer chip which can be embedded into almost any product. It uses an on-board microprocessor and an antenna to wirelessly transmit and receive certain information uniquely related to the item it is attached to. There are two types of RFID tags – passive and active tags [3]. The passive tag does not run on a battery, rather, it uses the electromagnetic field generated by the signal from the reader to power the processor and transmit information. This allows the chip to be small, inexpensive, and most importantly, since it does not require an on-board power source, the life of the tag is effectively unlimited. The RFID tag used in the suggested system uses the passive tag. However, the disadvantage of this type of tag falls on its range because it needs a signal from a reader to generate power. On the other hand, the active tag consists of an on-board power source which allows it to create its own signals which can be delivered to the reader over long distances. They usually operate at

433 MHz, 2.45 GHz, or 5.8 GHz, and they typically have a read range of 60 feet to 300 feet [3]. However, the drawback of this type of tag lies to its size due to the battery power. Active tags are used on large assets, such as cargo containers, rail cars and large containers, which need to be tracked over long distances.

This new era of technology application have promised improvements in productivity, security, and other benefits for a variety of industries. However, few applications have been developed that are related to the construction and facilities operations environment. Recently several attempts have been made to applying RFID technology to construction industry.

Ergen et al. [4] suggested using RFID in a facility management. They tested technological feasibility of using RFID within a facility repetitively on a daily basis with active RFID [5]. Song et al. [6] evaluated the use of RFID technology to be used tracking pipe spools through long supply chain. Schneider [7] asserted through his pilot studies that RFID is an effective method of reducing project activity times and saving project costs. Literature shows that RFID can benefit the construction industry with applications in a variety of management areas such as materials management, tracking of tools and equipment, automated equipment control, jobsite security, maintenance and service, document control, failure prevention, quality control, field operations, and construction safety.

## 3. PRODUCTION PLANNING AND WORKFORCE INFORMATION

Production planning, as distinct from project scheduling, appears to have been introduced into construction with the Last Planner® system [1, 8]. Production planning is a job making the best match of capacity and load achievable in given conditions [9]. A production planner needs information not only on task loads but also on resource capacity as shown in Figure 1.

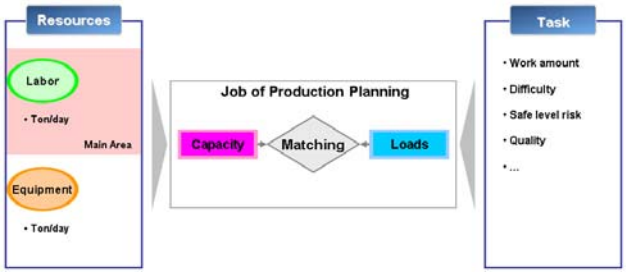


**Figure 1.** Production Planning Mechanism

Traditionally, task loads can be analyzed easily comparing to uncertainty of resource capacity. Especially, information on workforce capacity remains unknown in production planning in many cases while information on equipment capacity can be easily accessed. For example, the level of difficulty or demands of resources on each task can be measured and managed while information on labor capacity such as the level of workmanship is hard to be tracked and managed. However, such information on labor capacity is important in production planning in that it is a job of matching task loads with resource capacity. The critical process in production planning taking into accounts labor capacity is to generate and manage relevant information.

## 4. SUGGESTED WORKFORCE INFORMATION DATABASE SYSTEM USING RFID

### 4.1 RFID System

RFID is the next wave in the evolution of computing. It is a technology that connects objects to databases so that they can be tracked and shared with others. Figure 2 shows the system architecture of the RFID system to be used in the suggested workforce information database system.

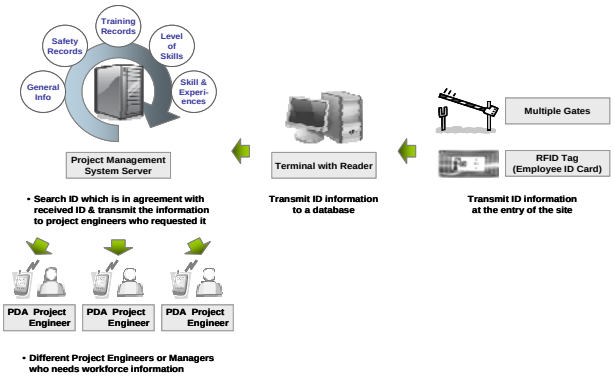


**Figure 2.** System Architecture for Manpower Management System using RFID

Employee ID cards have passive RFID tags and the reader scans the RFID tags when employees pass the gate where the reader is installed. The system operates at 13.56 MHz taking into account the readable range required on sites. The reader passes the information to the workforce information database system. This data can then be retrieved by the users who need the information for their production and safety planning.

### 4.2 Workforce Information Database System connected with RFID system

The authors surveyed 136 project engineers and managers to investigate what workforce information can be useful for their production/safety planning and control. Table 1 shows the survey results. In the system, the following information is tracked and managed.

- General personal information (age, nationality, passport number, workmanship);
- Safety records; and
- Work experience and the level of workmanship

**Table 1.** Survey Result on Useful Workforce Information

| Information | No. of people who selected the type of information | Percentage |
|---|---|---|
| **Job Classification** | 124 | 93.9% |
| **Accident record** | 121 | 91.7% |
| **Communication Skill** | 54 | 40.9% |
| **Level of Workmanship** | 116 | 87.9% |
| **Training record** | 71 | 53.8% |
| **Violation record** | 89 | 67.4% |
| **Work experience** | 85 | 64.4% |

* Total number of respondents, 132
; non-respondents, 4.

A simple database schema, designed for the workforce information databases, has been used. Figure 3 illustrates the ER-diagram for the databases, which shows the type of data and the relationships between data. Tables regarding general information include data on personal information, eligibility of work, and visa status. Tables regarding safety record include data on health, safety violation, and training records. Tables regarding work history and workmanship include employment history including previous projects and the level of workmanship.

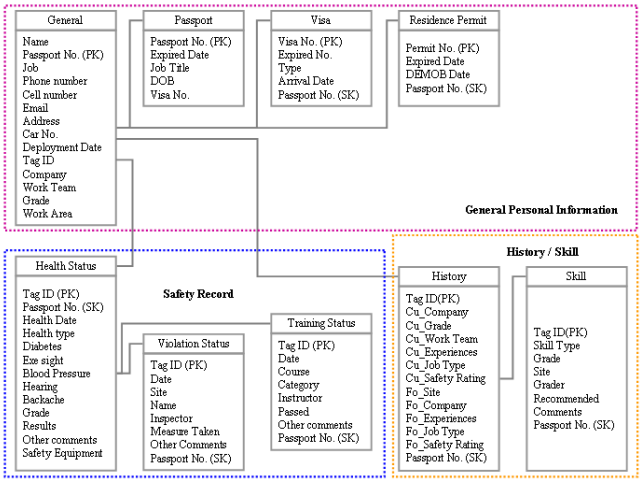


**Figure 3.** Entity Relation Diagram for Workforce Information Database

## 5. SYSTEM DESCRIPTION AND IMPLEMENTATION

In an attempt to achieve transparent and efficient workforce information management, a prototype workforce information database system is combined with RFID technology has been developed.

If a new worker arrives on site, information on a new worker needs to be registered in the workforce information database system. Once registered, he or she gets a temporary ID to which a passive RFID tag is attached. When he or she gets into site, he or she must scan his/her ID on the RFID reader. The information is sent to the workforce information database system the moment a tag is scanned. Front line mangers get exact information on how many people come on site, and when they arrived on the site instantly. Front line managers are also able to check information regarding their crew including general information (i.e., nationality and age), safety records, work history and workmanships on site through their PDA.

The example windows below show what information can be retrieved through the workforce information database system connected with RFID system. Figures 4, 5, 6, and 7 give actual screen dumps from the workforce information database system. Figures 4 and 5 show data input screens regarding general personal information. The Entry Form under the section of "general" allows the user to enter information about each labor's job, contact information, evidence of work eligibility, and work location

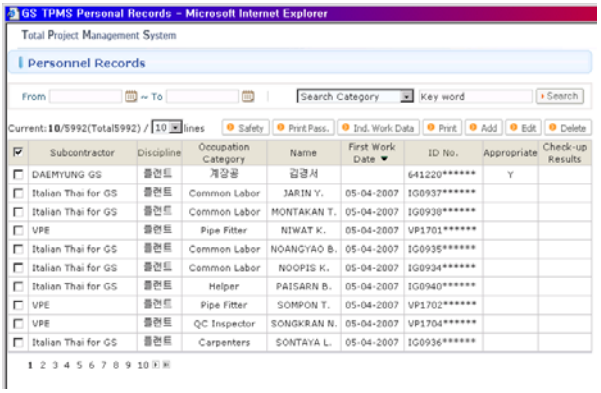


**Figure 4.** Personal records window

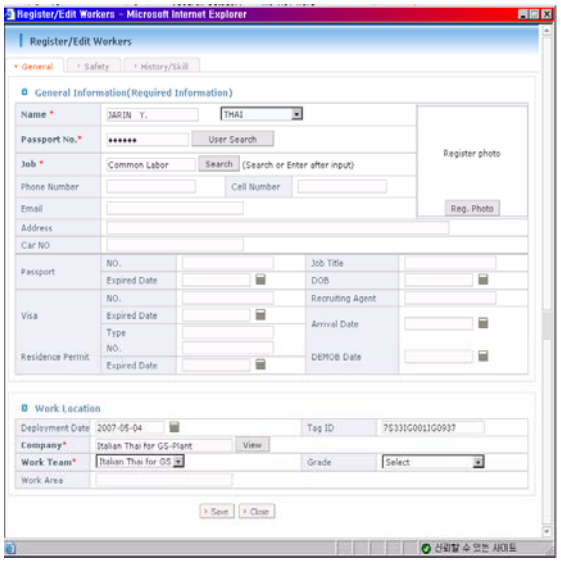


**Figure 5.** Personal records card

In the same manner, information about safety records is entered using data entry form as shown in Figure 6. Three types of safety data are updated and managed to prevent the safety accident. The first one is health status. Periodically or occasionally, all workers have to get a health test such as a blood pressure test. The second one is safety violation. If a worker does not wear a safety helmet, the violation record will be updated in the

workforce information database system. The third one is a safety training status.

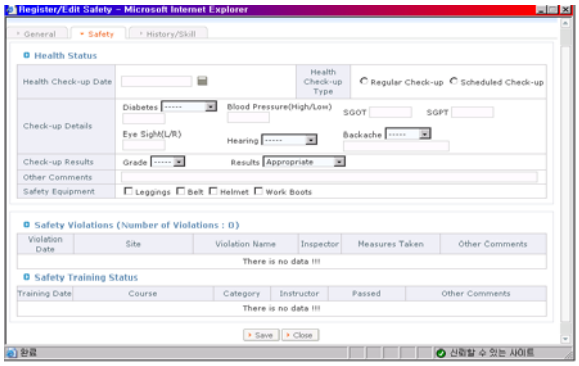


**Figure 6.** Safety records window

The database system also allows the user to enter work experience and the level of workmanship for each labor as shown in Figure 7. Sometimes managers have workforce information such as the level of workmanship. However, such information is not properly managed and maintained in many cases. The workforce information database system builds comprehensive information of each worker's capacity including the level of workmanship and safety records.

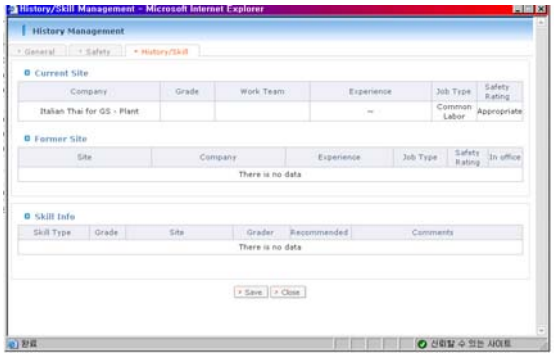


**Figure 7.** History/Skill window

The workforce database system allows the users to consider workforce capacity in production planning. As shown in Figure 8, for example, the user made comments to enforce safety field supervision taking into accounts the safety records. However, there is no guarantee that employees assigned to the task will show up.

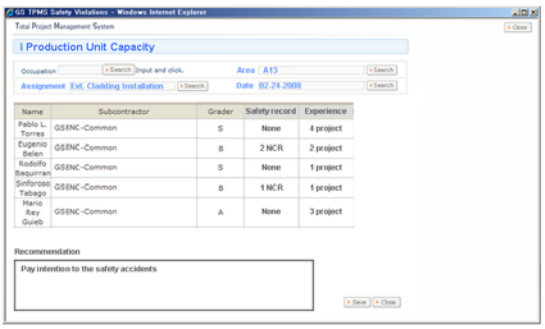


**Figure 8.** Example of Production Unit Capacity Screen for Production Planning

The system uses RFID technology to trace workforce information. When any labor gets into site, he or she must scan his/her ID on the RFID reader, and this information is sent to the workforce information database system (Figure 9). For example, one demonstration project set up four different gates through which every employee should scan his/her ID. Figure 10 shows layout of site and location of each gate where RFID antenna was installed. Front line managers are able to check information regarding their crew including general information (i.e., nationality and age), safety records, work history and workmanships on site through their PDA (Figure 11) as well as the number of their workforce on a specific job. In case where PU (production unit) members assigned to the task in the planning are different from employees who show up on sites, a frontline manger can react timely and effectively.

**Figure 9.** Issuing ID and scanning RFID reader

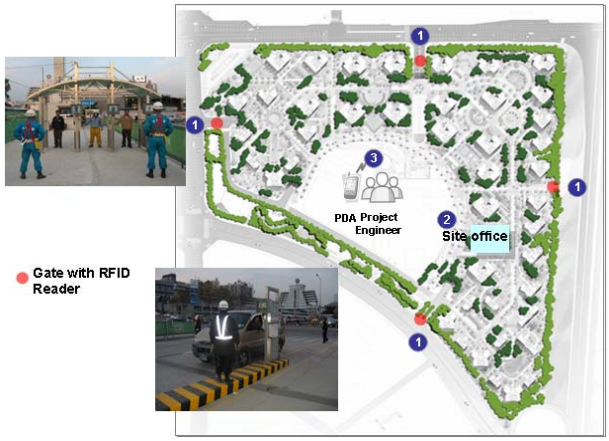


**Figure 10.** Site Layout and RFID Reader Location

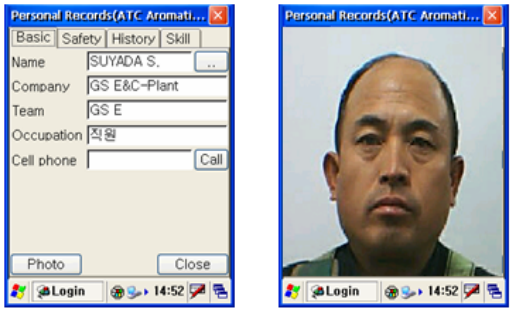


**Figure 11.** PDA window of a Frontline Manager

Many applications are possible using workforce information database system. If frontline managers need to know safety violation records or who violated safety regulations for the purpose of safety management, for

example, they can easily retrieve such information. The project in this example does not allow any worker who violated safety regulation more than two times. When retrieved between Feb. 01 and Feb. 24, safety violation records are shown in Figure 12. In the Figure 12, seven records are shown during the period, which provides frontline managers with insight into safety control.

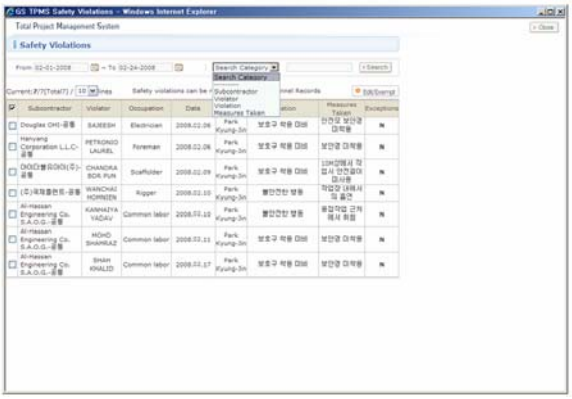

**Figure 12.** Safety violation status

## 6. DISCUSSION: BENEFITS AND CHALLENGES

### 6.1 Survey Methodology

The authors developed questionnaires to identify the benefits of the suggested system. The questionnaires were distributed to a group of five project mangers, and were revised according to comments from a pilot survey. A Likert scaling system was used for the questionnaire. This is a seven-point rating scale in which the attitude of the respondent is measured on a continuum from highly favorable to highly unfavorable, or vice versa, with an equal number of positive and negative response possibilities and one middle or neutral category [10].

The questions related to the suggested system are as follows;

Example question 1: Does this system help when you perform production planning?

Example question 2: Does this system help when you count the number of crew on site?

System users who experienced a system were asked to answer the questionnaire and provide comments. Table 2 shows results of a survey using seven-point Likert scale questions, in which a score of "1" corresponds to "Least Helpful" and a score of "7" corresponds to "Most Helpful".

### 6.2 Benefits from Workforce Information Database Using RFID Technology

Benefits from the suggested system have been identified in Table 2 and they are grouped into three categories throughout the survey:

1) Traces workforce information on workforce capacity for production and safety planning

In the current model, only safety information, which includes safety-related violation records and safety training history for each worker, is used for production planning. The system tells a frontline manager if any crewmember has safety records that go beyond the customized tolerance level. These built-in alarms allow a frontline manager to strengthen the level of safety supervision. In addition, there is great potential to use workforce information in the contractor's production planning.

2) Reduces time consumed to count the number of crew on site

The most direct, but not necessarily the most substantial, benefit is reduced time and effort in counting the number of workforce. In the traditional approach, each frontline manager spends 5 to 20 minutes in head-counting on a daily basis. Through RFID systems no resources are required to count the number of crew on site. The information can be easily grouped into work divisions or work areas. Additionally, such information is connected to the accounting system which automatically collects information on the number of working hours or days on each individual. The time required for processing time cards for employees has been reduced without question.

**Table 2.** Survey Result on Benefits with the Proposed System

| Information | | No. | Production planning | Safety planning | Time of Counting | Work-force security | Accuracy of system | Tool of career management | Easy to operate | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| **Commercial Building project (23 sites)** | **Foremen** | 7 | 6.1 | 6.0 | 6.3 | 5.1 | 6.8 | 3.5 | 2.5 | 5.2 |
| | **Superintendents** | 6 | 5.8 | 5.5 | 6.4 | 4.5 | 6.6 | 3.0 | 2.8 | 4.9 |
| | **Field Engineers** | 8 | 6.3 | 6.1 | 6.6 | 4.4 | 6.6 | 2.5 | 3.4 | 5.1 |
| | **Site Managers** | 4 | 6.4 | 6.2 | 6.1 | 4.8 | 6.8 | 3.0 | 3.0 | 5.2 |
| **Residential project (31 sites)** | **Foremen** | 9 | 6.0 | 5.5 | 6.6 | 5.0 | 6.6 | 2.5 | 2.4 | 4.9 |
| | **Superintendents** | 8 | 5.9 | 5.2 | 6.7 | 5.2 | 6.8 | 2.6 | 2.1 | 4.9 |
| | **Field Engineers** | 15 | 6.4 | 5.8 | 6.4 | 4.5 | 6.6 | 3.0 | 3.5 | 5.2 |
| | **Site Managers** | 9 | 6.1 | 5.5 | 6.2 | 4.6 | 6.2 | 3.5 | 3.1 | 5.0 |
| **Civil project (14 sites)** | **Foremen** | 4 | 5.5 | 5.0 | 6.3 | 4.2 | 6.4 | 2.8 | 2.2 | 4.6 |
| | **Superintendents** | 5 | 5.3 | 5.2 | 6.4 | 4.8 | 6.5 | 3.2 | 2.0 | 4.8 |
| | **Field Engineers** | 3 | 6.0 | 5.8 | 6.5 | 5.0 | 6.4 | 3.6 | 2.8 | 5.2 |
| | **Site Managers** | 3 | 5.9 | 5.6 | 6.6 | 5.2 | 6.6 | 3.6 | 2.6 | 5.2 |
| **Industrial project (8 sites)** | **Foremen** | 2 | 6.0 | 6.0 | 6.0 | 5.5 | 6.5 | 3.5 | 3.0 | 5.2 |
| | **Superintendents** | 4 | 5.8 | 5.2 | 6.4 | 5.3 | 6.4 | 3.7 | 3.3 | 5.2 |
| | **Field Engineers** | 3 | 5.9 | 5.2 | 6.0 | 5.3 | 6.2 | 3.3 | 3.5 | 5.1 |
| | **Site Managers** | 1 | 6.0 | 5.0 | 6.0 | 5.0 | 6.0 | 3.0 | 4.0 | 5.0 |
| **Total / Average** | | **91** | **6.0** | **5.6** | **6.3** | **4.9** | **6.5** | **3.1** | **2.9** | - |

* Total number of respondents, 91, 1 = Least Helpful, 7 = Most Helpful

3) Provides error-proof information on workforce security

Other immediate benefits from the use of RFID technology in tracking workforce information are a function of its capability to check the security. The security issues include identifying illegal workers. For example, the workers who do not have valid work permits or working visas are easily identified.

### 6.3 Challenges with the system

In addition to the survey to explore the benefits from implementing a new labor information tracking system using RFID, the authors interviewed twelve superintendent and project managers to identify limitations and challenges in implementing the suggested system. We avoided a standardized survey to capture different perspectives of people who experienced the system. Here are the lists of limitations and challenges that have been identified.

1) When one laborer works on more than two different jobs in a day the system does not automatically trace and allocate his or her wage into a different cost code. Some performance information such as productivity data for each cost code is not generated unless a foreman manually allocates the proportion of his or her time to different cost codes.

2) Workforce information could be incomplete or distorted if workers had worked for different company (i.e., different contractor). It is because the database system is not shared with other contractors.

3) Workforce information for a squad is currently not available since current information is collected at the individual level. The information would be more informative to production planners if information for squads could be traced and controlled as well.

## 7. CONCLUSIONS AND MOVING FORWARD

This paper describes a prototype workforce information database system which focuses on tracking daily workforce production information on sites. The system uses RFID technology to track workforce information. The workforce information controlled in the system includes work history, skills, training records as well as personal records. In addition to a survey for identifying benefits, the paper presented a list of challenges through a series of interviews. The next phase of the study evaluates how such information on workforce capacity is utilized in production planning relative to the loads of the tasks. Other researchers working in this area are encouraged to contact the authors to share ideas and coordinate future research.

## 8. ACKNOWLEDGEMENT

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